Rules and Regulations for the Construction and Classification of Steel Ships

Part 1

Regulations

July 2016

IRCLASS

Indian Register of Shipping

General Information

This consolidated version of the ‘Rules and Regulations for the Construction and Classification of Steel Ships’ (July, 2016) supersedes the July, 2015 edition of the Rules and includes the amendments published in Rules Change Notice No.1 of October, 2015 and Rules Change Notice No.2 of January, 2016.

A summary of additions and amendments incorporated in this consolidated version (further to amendments in Rule Change Notice No.1 of October, 2015 and Rule Change Notice No.2 of January, 2016) are indicated in Table 1.

RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS – JULY 2016

TABLE 1 – AMENDMENTS INCORPORATED

These amendments will come into force as indicated in the Table

Section / Clause	**Subject / Amendments**
Part 1 Chapter 1 : General *The amendments are effective from 01 July 2016*	
1/1.9.1 &1.9.4	The term "surveys" is changed to appropriate term "inspections"
1/1.9.2 & 19.3	Requirement of verification of performance of service providers is added.
2/2.9.2	"Alternative Certification Scheme" (given in new section 4) is added as an option for certification of materials, components, equipment and machinery.
2/2.18.1.1	It is clarified that automatic suspension will be made only after the expiry of any extension granted to the certificate of class.
2/2.21	Reference is made to the requirements for transparency of information in Rules for Bulk Carriers and Tankers for vessels where IMO Goal Based Standards are applicable.
4	New section indicating requirements of Alternative Certification Scheme based upon QMS is added.
Part 1 Chapter 2 : Periodical Surveys *The amendments are applicable to surveys commenced on or after 01 July 2016*	
1/1.1.3	The clause is re-worded to reflect the present status of HSSC.
1/1.10.1	It is clarified that when the scope of annual surveys are increased to that of intermediate or special surveys and scope of intermediate surveys are increased to that of special surveys: thickness measurements, as per relevant tables, are to be carried out.
2/2.4.7.4	Requirements for close up survey and thickness measurements of hatch cover and coaming are now given in relevant tables.
2/Table 2.4.9.1 a), b) and c) ; 6/6.4.5.1, Table 6.4.7.1 and Table 6.4.8.1 a)	It is clarified that, for inaccessible internal structures of approved hatch covers, close up survey and TM are not required.
2/ Table 2.4.9.1 b)	Requirements for close up survey of side structure of bulk carriers: Transverse framing and Longitudinal framing system members are specified.
3/3.4.7, 4/4.4.7	It is clarified that tank testing procedure is to specify fill heights, tank being filled and bulkheads being tested.
3/Table 3.4.8.1 b), 4/Table 4.4.8.1 b)	Under note 7 "longitudinal bulkhead vertical girder" has been amended to "longitudinal bulkhead structural elements"
9/9.1.1 & 9.1.9	Possibility of extension of boiler surveys by 3 months beyond due date shifted from 9.1.9 to 9.1.1
18	New Section added (Section 18) stipulating requirements for periodical surveys of diving systems
Part 2 Chapter 1 : General Requirements *The amendments are effective from 01 July 2016*	
2	Reference is made to Part 1 Chapter 1 for general requirements for ACS and duplicated requirements in this chapter are deleted. Specific requirements for materials are retained.

Section / Clause	Subject / Amendments
Part 3 Chapter 5 : Longitudinal Strength *The amendments are applicable to ships contracted for construction on or after 01 July 2016*	
1/1.1.6	It is clarified that the requirements for longitudinal strength in this section do not apply to Container ships. Separate requirements for container ships are given in Pt.5, Ch.5, Sec.4.
Part 3 Chapter 6 : Bar Keel, Stem and Sternframe *The amendments are applicable to ships contracted for construction on or after 01 July 2016*	
4/4.3 & 4.5	Requirements for the structural strength of sole pieces and rudder horns have been indicated in Pt.3, Ch.14, Sec.7. Hence, the existing structural strength requirements in Pt.3, Ch.6 for sole pieces and rudder horn are deleted
Part 3 Chapter 12 : Opening and Closing Appliances *The amendments are applicable to ships contracted for construction on or after 01 July 2016*	
1/1.3.2	A note is added which clarifies that the horizontal design weather load need not be considered for the direct strength calculation unless it is used in the sub structures of horizontal support.
1/1.3.3	Several editorial changes are made in the requirements for cargo loads for better understanding.
1/1.3.4.2	The loads at each corner of container stack resulting from heave and pitch are specified.
1/1.3.4.4	Load cases with partial loading of containers are specified. Existing Fig.1.3.4.1 has been deleted and new Fig.1.3.4.4 is added. The partial loading for each Heel direction is indicated in the figure.
1/1.3.4.5	Requirements for the case of mixed stowage of 20 feet and 40 feet containers are added.
1/1.5	The corrosion additions and steel renewal requirements of hatch covers are given in this sub-section.
2/2.2.9	It is clarified that materials for hatch coaming are to satisfy the requirements of Pt. 2, Ch.2.
2/2.5.1	The types of hatch coaming stay constructions where simple beam analysis may be used and those requiring FEM analysis are separately shown in Fig.2.5.1.
2/2.6.4	Requirement for extension of coaming plate is added. Fig.2.6.4 gives example of hatch side girder.
3/3.1.3	It is clarified that materials of hatch covers are to comply with Pt.3, Ch.2 with Class I for top plate, bottom plate and primary support members.
3/3.3.1	Guidance on evaluation of stresses in finite elements of flanges of unsymmetrical girders is added
3/3.4	Fig.3.2 for determination of normal stresses is modified indicating that maximum stresses in the panel are to be considered .
3/3.4.2	The requirement of plate thickness when normal cargo is carried and when project cargo is carried are separated. Definition of project cargo is given in note.
3/3.5	Separate formula given for requirements of secondary stiffeners for considering weather loads and cargo loads.
3/3.7	It is clarified that double skin hatch covers or hatch covers with box girders are to be assessed using FEM.
4/4.4.1	It is clarified that accelerations in longitudinal and transverse directions need not be considered simultaneously.
4/4.4.2	Note added to clarify conditions for relaxation in permissible nominal surface pressures for hatch cover supports.

Section / Clause	Subject / Amendments
Part 3 Chapter 14 : Rudders *The amendments are applicable to ships contracted for construction on or after 01 July 2016*	
1/1.1	General requirements regarding acceptance of alternatives to the rules are indicated.
3/Table 3.1.1	Factor K2 for calculation of Rudder force for additional rudder profile types are given.
3/3.3.2	Detailed guidelines for calculating Bending moments and shear force distribution for various types of rudders are given in Sec.8 (new). Existing formulae in 3.3.2 are deleted.
4/4.1.2	Requirements for welding between plates and heavy pieces are given.
4/4.1.3 & 4.1.4	Existing 4.1.3 deleted and 4.1.4 has been renumbered. Details for slot welding are provided
4/ 4.1.5 to 4.1.8	New clauses added clarifying construction requirements for rudder blades.
4/4.3	Requirements for scantlings of rudder stock, blade and arms of single plated rudder are given.
4/4.4	Details of connection of solid parts with rudder blade are specified.
5/5.1.7	It is specified that where significant reductions in rudder stock diameter is achieved by using high strength steels, deformations are to be checked.
5/5.2.3	Requirement for Push up pressure of pintle bearings is specified.
5/5.3	Requirements for thickness of liners and bushes and minimum bearing surface area and maximum pressures are specified.
6/6.1.6	Detail of welded joint between rudder stock and coupling flange is given in Fig.6.1.6.
6/6.3	Requirements added for key dimensions for rudder couplings.
6/6.4	New formulae for push up pressure and push up length for rudder couplings are added.
7	Requirements for the structural strength of sole pieces and rudder horns have been indicated.
8	This section gives guidelines for calculation of BM, SF and support reactions on Rudder –Rudder stock system for various types of rudders.
Part 4 Chapter 1 : General Requirements for Design and Construction of Machinery *The amendments are effective from 01 July 2016*	
4/4.1	The existing requirements for certification based on QMS are deleted and reference is made to Pt.1. Ch.1, Sec.4.
4/4.2.1	It is clarified that in the case of diesel engines, ACS can be considered only where engines are type approved.
4/4.2.2	Individual components of diesel engines are to be certified in accordance with the new Classification Notes “ Approval of IC engines”.
Part 4 Chapter 4 : Prime Movers and Propulsion Shafting System	
4/4.1	*The amendments are effective from 01 July 2016* Reference is made to new Classification notes “Approval of IC engines” which covers documentation for approval, type testing and certification of engine components. The corresponding existing requirements in this chapter are deleted.
4/4.11	*The amendments are applicable to engines with an application for certification dated on or after 01 July 2016.* Requirements for Factory acceptance tests are added: This includes works trials in 4.11.3
4/4.12	*The amendments are applicable to engines:* *i) with an application for certification dated on or after 01 July 2016; or* *ii) installed on ships contracted for construction on or after 01 July 2016.* Requirements for test loads for various types of engine applications are added in Table 4.12.5.1 a) to e)

Section / Clause	Subject / Amendments
10	*The amendments are effective from 01 July 2016* Section 10 : “Turbochargers” is deleted as the requirements are now covered in classification notes “ Approval of IC engines”.
Part 4 Chapter 5 : Boilers and Pressure Vessels *The amendments are applicable to shell type exhaust gas heated economizers:* *i) when an application for certification of a shell type exhaust gas heated economizers is dated on or after 01 July 2016; or* *ii) which are installed onships contracted for construction on or after 01 July 2016*.	
3/3.2.1.9 b) and c)	3.2.1.9 b) and c) are deleted as operating practices are more relevant than design measures in this case.
Part 4 Chapter 8 : Electrical Installations *The amendments are effective from 01 July 2016*	
12/12.6	Reference is given to specific IEC standard 60092-503 for creepage distances and existing requirements are deleted.
12/12.11.4	It is specified that shutters of withdrawable circuit breakers are to be clearly marked for incoming and outgoing circuits
12/12.11.6	Internal arc classification for switchgear and control gear is specified
12/12.13	Requirement for clear working space in the vicinity of equipment. Ceiling/ deckhead clearances to meet internal arc classification requirements.
12/12.13.2	Voltage withstand test requirements after installation are harmonized with that of IEC 60502(1) and 60502(2)
Part 5 Chapter 1 : Dry Bulk Cargo Carriers *The amendments are applicable to ships contracted for construction on or after 01 July 2016*	
1/1.6.15	Where vertical ladders are installed with ladder linking platforms, the offset distances and arrangements are specified in Figure A and B.
Part 5 Chapter 4 : Liquefied Gas Carriers *The amendments are applicable to Gas Carriers constructed on or after 01 July 2016*	
All sections	The chapter has been completely revised in accordance with revised IGC Code (MSC 370(93)) and revised IACS UIs.
Part 5 Chapter 5 : Container Ships *The amendments are applicable to Container Ships contracted for construction on or after 01 July 2016*	
4	Requirements for hull girder strength in Section 4 have been completely revised in accordance with new IACS UR S11A
5	Existing Section 5 has been renumbered to Section 9. Existing requirements for local structure shifted from Section 4 to Section 5
6	Method for buckling assessment for container ships is elaborated.
7	Method for calculation of ultimate hull girder strength is given in this section.
8	Functional requirements and load cases for FE analysis are specified.
Part 5 Chapter 26 : Diving Support Vessels and Diving Systems *The amendments are effective from 01 July 2016*	
All sections	The chapter has been completely revised, to allow classification of diving systems independently from diving support vessels. The revised chapter also incorporates IMO requirements for Code of Safety for Diving Systems (A.831(19))

Section / Clause	Subject / Amendments
Part 6 Chapter 2 : Prevention of Fire and Explosion *The amendments are effective from 01 July 2016*	
2/IR 2.2.1.3	It is clarified that the fan in a HVAC control unit or a circulation fan inside a cabinet/ switchboard is not considered to be a ventilation fan if they are not capable of supplying outside air to the space when the power ventilation is shut down.
Part 6 Chapter 3 : Suppression of Fire *The amendments are applicable to all ships contracted for construction on or after 01 July 2016*	
4/4.5.2	The amendment clarifies the application of 4.5.2 relevant to the provision of additional fire-extinguishing arrangements. The word "of category A" were added to read : "Machinery spaces of category A containing internal combustion machinery"
Part 6 Chapter 4 : Escape *The amendments are applicable to ships contracted for construction on or after 01 Feb 2016*	
2/IR 2.3.3.3	It is clarified that the lowest open deck is an open deck (defined in Ch.3) at the lowest height from base line in way of accommodation spaces.
2/IR 2.4.1	Interpretations of escape routes are provided. Clear width in escape trunks are indicated by Fig.2.4.1.4.1.
2/IR 2.4.2.2.1 new	It is clarified that steering gear spaces which do not contain emergency steering position need only have one means of escape. Where it contains emergency steering position, one means of escape can be accepted if it leads directly to open deck.
2/IR 2.4.2	Interpretations for escape routes for cargo ships similar to that in 2.4.1 for passenger ships.

Indian Register of Shipping

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Section 1

General Information

1.1 Indian Register of Shipping

1.1.1 Indian Register of Shipping (hereinafter referred to as "IRS") was incorporated in 1975 as a Public Limited Company under Section 25 of the Indian Companies Act, 1956 for the purpose of providing amongst other things a faithful and accurate classification of mercantile shipping classed with it, to approve designs of, to survey and to issue reports on mercantile and non mercantile ships, hovercrafts, hydrofoils etc; all within the scope of classification described in the Rules. This Section contains General Regulations which have been adopted by IRS for its governance.

1.1.2 The management of the affairs of IRS are carried out under the direction and control of the Board of Directors (hereinafter referred to as the 'Board'), in accordance with the provisions of its Memorandum and Articles of Association.

1.1.3 The Board of Directors shall consist of representative of the interests of various members of the Company and those concerned with shipping in general as under:

3	Directors representing Indian Shipowners
2	Directors representing Indian Shipbuilders
1	Director representing General Insurance Corporation of India and other Indian underwriters
1	Director being the Director General of Shipping, Ministry of Surface Transport, Govt. of India
1	Director representing Ship Design Research and Development Institutions
1	Director representing Manufacturers of Marine Engines/General Engineering Goods
1	Director representing Indian Navy/Coast Guard
1	Director being a person of eminence from the field of Law
3	Directors being persons of eminence from any industry allied with maritime activities
1	Managing Director being full-time employee appointed by the Board of Directors.

The composition of the Board as above is to be in accordance with the Articles of Association of IRS (as may be amended from time to time).

1.1.4 The Board shall consist of not less than six and not more than fifteen Directors. The Board of Directors shall elect one of its members to be Chairman of the Board of Directors.

1.1.5 The Board is to appoint a Sub-Committee of Classification representing concerned interests.

1.1.6 The Board is to appoint the Chairman of the Sub-Committee of Classification and the Managing Director, IRS to be 'ex- officio' member of the Sub-Committee of Classification.

1.1.7 The employees of IRS are to be appointed by and be under the direction of the Board.

1.1.8 The Surveyors of IRS are not to be permitted without the special sanction of the Board of Directors to receive any fee, gratuity or reward whatsoever, for their own use or benefit, for any service performed by them in their capacity as Surveyors to IRS, except on pain of immediate dismissal.

1.1.9 The Funds and Accounts are to be under the authority and control of the Board of Directors.

1.2 Fees

1.2.1 Fees will be charged for all surveys and for other services rendered by IRS or any of its publications in accordance with established scales. Traveling expenses incurred by the Surveyors in connection with such services are also chargeable.

1.3 Technical committee

1.3.1 The Board is to appoint a Technical Committee whose function will be to consider:-

a) Formulation of Technical Rules for Classification Surveys, building of ships, their machinery and equipment.

b) Important alterations to Rules once framed as may be required from time to time.

1.3.2 All decisions of the Technical Committee including amendments and/or additions to the Rules for classification surveys and building of ships' hull, their machinery and equipment to be reported to the Board of Directors.

1.3.3 The Technical Committee to be constituted as follows:

Number of Members	**Nominees/Representatives of**
3	Board of Directors of IRS
1	Marine Engine Unit of M/s. Garden Reach Ship-builders and Engineers Ltd.
1	Other Marine Engine Builders
6	Shipbuilders
2	Indian Institution of Naval Architects
2	Institute of Marine Engineers (India)
1	Company of Master Mariners
2	Directorate General of Shipping
1	IMU (Earlier NSDRC)
4	Indian National Shipowners Association
1	Institution of Engineers (India)
1	Ex-Officio - Managing Director of IRS or his nominee
1	Indian Coastal Conference Shipping Association
1	Oil Industry Safety Directorate
5	Indian Navy
2	Indian Coast Guard
1	Research Institutes
2	Indian Institute of Technology/ National Institute of Technology
2	Maritime Training Institutes
3	Other Flag Administrations
1	Inland Waterways Authority of India.

1.3.4 In addition to the foregoing, the Technical Committee may co-opt to the main body other members of high managerial positions in Ship Building and Engineering, Naval Architecture, Marine Insurance, Steel Making, etc.

1.3.5 Nomination of all members to the Technical Committee to be subject to confirmation by the Board.

1.3.6 The Technical Committee can appoint panels from amongst its body to which representatives of any organisation or industry or individuals specialised in relevant disciplines could be co-opted for the purpose of considering any particular Technical problem or area of Rules.

1.3.7 The Board of Directors to appoint biennially, the Chairman of the Technical Committee and the Technical Committee to appoint from their own body biennially a Vice-Chairman. The appointment of Vice-Chairman to be confirmed by the Board of Directors.

1.3.8 The terms of office of all members to be not more than four years, one-fourth of all members (including those co-opted) to retire at the end of each calender year. The members so retiring being those who have been longest in office since their last nomination and such members to be eligible for re-nomination for a second term. Unless specially so authorised by the Board of Directors, no member other than Chairman and/or Vice- Chairman, who has served for two periods of nomination, to be eligible for re-nomination. In the event of any vacancy occurring before the expiration of the normal term of office, a representative to be nominated to fill the vacancy from the same group/body/institution and for such nominee the date of his nomination by the respective body to be considered as date of his joining the Technical Committee for purposes of his retirement by rotation.

1.3.9 The meeting of the Technical Committee to be convened as often and at such time and place as may appear necessary, but there shall be at least two meetings in each year.

1.3.10 The members desiring to propose alterations in, or additions to the Rules for the classification, survey or building of ship (hull and machinery) shall give notice of such proposals to the Secretary. Every meeting to be convened by notice from the Secretary, if possible one month before the date of the meeting and the Secretary to send to each member an Agenda paper as soon as possible thereafter.
Proposals for changes to rules may also be given by Flag Administrations, shipowners, shipbuilders and other interested parties who may not be represented in the Technical Committee.

1.3.11 The quorum for any meeting of Technical committee will be six members, with at least 50% of the members present being those who do not represent shipowners, shipbuilders or others engaged commercially in the manufacture, equipping, repair or operation of ships.

1.3.12 In the event that any matter is not decided by unanimity, the same may be decided by a majority of votes cast in favor, with each member, including co-opted members, having one vote only. In the event of a parity of votes, the Chairman of the Technical Committee would be entitled to an additional casting vote.

1.3.13 When any discussion relates to an item of interest to those representing shipowners, shipbuilders or others engaged commercially in the manufacture, equipping, repair or operation of ships, such representatives would not be entitled to vote, if such matter is to be decided by voting.

1.3.14 In the event that any member of the Technical Committee absents himself for 3 consecutive meetings of the Technical Committee without seeking leave of absence, he would be deemed to have vacated office and his vacancy would be filled by seeking fresh nomination from concerned interest represented.

1.3.15 In the absence of the Chairman & the Vice Chairman of the Technical Committee, the members of the Technical committee shall elect a Chairman, by majority vote, to preside over that particular meeting only.

1.3.16 The Board of Directors reserves to themselves the right of altering, adding to or rescinding any/or all of the above terms of reference including the dissolution of the Technical Committee.

1.4 Survey reports

1.4.1 All reports of survey are to be made by the Surveyors according to the form prescribed and submitted for consideration of the Board or the Sub-Committee of Classification, but the character assigned by the latter is to be reported to the Board. The Board may, in specified instances, vest in the Managing Director discretionary powers to act on its behalf, and all such actions being reported to the Board at its subsequent meeting.

1.4.2 The reports of the Surveyors shall, subject to the approval of the Managing Director, be open to inspection of the Owner and any other person authorised in writing by the Owner. Copies of the reports will, subject to the approval of the Managing Director, be supplied to Owners or their representatives.

1.5 Register of Ships

1.5.1 A Register Of Ships is available on-line on IRCLASS Website which contains the names of ships, character of class and notations assigned together with other relevant useful information for ships classed with IRS.

1.6 Liability

1.6.1 Whilst Indian Register of Shipping (hereinafter referred to as IRS) and its Board/Committees use their best endeavours to ensure that the functions of IRS are properly carried out, in providing services, information or advice, neither IRS nor any of its servants or agents warrants the accuracy of any information or advice supplied. Except as set out herein, neither IRS nor any of its servants or agents (on behalf of each of whom IRS has agreed this clause) shall be liable for any loss damage or expense whatever sustained by any person due to any act or omission or error of whatsoever nature and howsoever caused of IRS, its servants or agents or due to any inaccuracy of whatsoever nature and howsoever caused in any information or advice given in any way whatsoever by or on behalf of IRS, even if held to amount to a breach of warranty. Nevertheless, if any person uses services of IRS, or relies on any information or advice given by or on behalf of IRS and suffers loss, damage or expenses thereby which is proved to have been due to any negligent act omission or error of IRS its servants or agents or any negligent inaccuracy in information or advice given by or on behalf of IRS then IRS will pay compensation to such person for his proved loss up to but not exceeding the amount of the fee charged by IRS for that particular service, information or advice.

1.6.2 Any notice of claim for loss, damage or expense as referred to in 1.6.1 shall be made in writing to IRS Head Office within six months of the date when the service, information or advice was first provided, failing which all the rights to any such claim shall be forfeited and IRS shall be relieved and discharged from all liabilities.

1.7 Audits and assessments by external organizations

1.7.1 The surveys required by the regulations, and conducted by IRS may be subject to Audit by an independent Accredited Certification Body (ACB) as per the requirements of ISO 9001:2008 standard and Quality Management System Certification Scheme (QSCS) of IACS. For this purpose, ACB auditors are to be given the necessary access to the ship, shipyard or works when requested by IRS.

Access is also to be given to auditors or inspectors accompanying the Surveyors as required by other external organizations.

1.8 Access of Surveyor to ships, shipyards or works

1.8.1 The Surveyors are to be given free access to ships classed with IRS as well as to shipyards, works, etc. so as to perform their duties, and are to receive adequate assistance for this purpose.

1.9 Requirements for service suppliers

1.9.1 In general, the following categories of service suppliers are to be approved:

a) Classification and / or Statutory services

- Firms engaged in thickness measurements on ships
- Firms engaged in tightness testing of closing appliances such as hatches, doors, etc with ultrasonic equipment
- Firms carrying out in-water survey of ships and mobile offshore units.
- Firms engaged in the examination of Ro-ro ships, bow, stern, side and inner doors.
- Firms engaged in measurement of noise levels onboard ships
- Firms engaged in tightness testing of primary and secondary barriers of gas carriers with membrane cargo containment systems for vessels in service.
- Firms engaged in inspections and maintenance of fire extinguishing equipment and systems
- Firms engaged in testing of coating systems in accordance with the requirements of IMO performance standards for protective coatings.

b) Statutory services

- Firms engaged in servicing inflatable liferafts, inflatable lifejackets, hydrostatic release units, inflatable rescue boats, marine evacuation systems, etc.

- Firms engaged in the inspections and testing of radio communication equipment

- Firms engaged in inspections and maintenance of self contained breathing apparatus

- Firms engaged in the annual performance testing of voyage data recorder and simplified voyage data recorders

- Firms engaged in the inspections of low location lighting systems using photo luminescent materials and evacuation guidance systems used as an alternative to low location lighting systems

- Firms engaged in sound pressure level measurements of public address and general alarm systems on board ships

- Firms engaged in the servicing and maintenance of lifeboats, launching appliances, on-load release gear and davit-launched liferaft automatic release hooks

- Firms engaged in the inspection, performance testing and maintenance of Automatic Identification Systems (AIS).

1.9.2 Where the results of the following service providers are used by a Surveyor of IRS in making decisions affecting Classification services, then that service provider is to be approved and service performance verified by IRS:

- Firms engaged in thickness measurements on ships

- Firms carrying out in-water survey of ships and mobile offshore units

- Firms engaged in tightness testing of closing appliances such as hatches, doors etc with ultrasonic equipment

IRS may also accept the services of firms approved by other IACS member classification societies for such services other than those listed above.

1.9.3 Where services are used by the Surveyors in making decisions affecting statutory certification and services, the firms are subject to approval and performance verification by IRS, where IRS is so authorized by the relevant Flag Administration (i.e. the Flag of the ship on which the servicing is to be done or the service equipment is to be used). For such services, IRS may accept approvals done by:

I. The Flag Administration itself,
II. Duly authorized organisation acting on behalf of the Flag Administration, or
III. Other organizations those are acceptable to the Flag Administration (e.g. other governments etc).

1.9.4 Use of the approved service suppliers is not mandatory for the following services, unless instructed otherwise by the flag Administration with respect to statutory certification:

- Firms engaged in the inspections of low location lighting systems using photo luminescent materials and evacuation guidance systems used as an alternative to low location lighting systems

- Firms engaged in sound pressure level measurements of public address and general alarm systems on board ships

- Firms engaged in measurement of noise levels onboard ships

- Firms engaged in testing of coating systems in accordance with the requirements of IMO performance standards for protective coatings.

- Firms engaged in the examination of bow, stern, side and inner doors.

1.10 Responding to Port State Control

1.10.1 When requested by Port State and upon concurrence by the vessel's owner/master IRS Surveyors would attend onboard a ship in order to assist in the rectification of reported deficiencies or other discrepancies that affect or may affect classification or the statutory certificates issued by IRS. The owner and the vessel's flag state will be notified of such attendance and survey. IRS Surveyors will also cooperate with Port States by providing inspectors with background information.

Section 2

Classification Regulations

2.1 General

2.1.1 When a ship is assigned a specific Character of Class by Indian Register of Shipping, it implies that IRS has been satisfied that the said ship meets, for this particular class, with these Rules and Regulations or requirements equivalent thereto. The ship will continue to be classed with IRS so long as she is found, upon examination at the prescribed annual and periodical surveys, to be maintained in a fit and efficient condition and in accordance with the Periodical Survey requirements of these Rules. Classification will be conditional upon compliance with IRS requirements and assignment of character of class for both hull and machinery.

2.1.2 The Rules are framed on the understanding that ships will be properly loaded and handled; they do not, unless stated in the class notation, provide for special distributions or concentrations of loading and that ships will not be operated in environmental conditions more severe than those agreed for design basis and approval.

2.1.3 Compliance with the following IMO conventions, codes and resolutions, as amended, and as applicable, is a pre-requisite of classification:

- International Convention on Loadlines (ILLC)
- International Convention for the Safety of Life at Sea (SOLAS)
- International Convention for the Prevention of Pollution from Ships (MARPOL)
- International Convention on the Control of Harmful Antifouling Systems on Ships (AFS Convention)
- International Bulk Chemical Code (IBC Code) or Bulk Chemical Code (BCH Code)
- International Gas Carrier Code (IGC Code) or Gas Carrier Code (GC Code)
- Fire Test Procedures Code (FTP Code) of the International Maritime Organization (IMO)
- Codes on noise levels on board ships.
- Related Resolutions of the IMO Assembly, the Maritime Safety Committee (MSC) and the Marine Environment Protection Committee (MEPC) of IMO.

In addition, the Unified Interpretations of IACS (International Association of Classification Societies) related to the above IMO Conventions and Codes are also to be complied with unless provided with written instruction to apply a different interpretation by the flag Administration.

2.1.4 Where a vessel holds dual classification with IRS and the periodical survey requirements of the corresponding Society differ from those of the Rules of IRS, IRS may permit the requirements of the corresponding Society being applied, in so far as they are equivalent in purpose or are no less stringent than the IRS rule requirement.

2.1.5 The classification of a ship with IRS does not exempt the owners from compliance with any additional and/or more stringent requirements issued by the Administration of the state whose flag the ship is entitled to fly and provision for their application.

2.1.6 It is the responsibility of the Owners to ensure that the operating and maintenance instructions/manuals for the ship machinery equipment essential to the safe operation of the ship are available in a language understandable by those officers and crew members who are required to understand such information /instructions in the performance of their duties.

2.1.7 When a ship is detained by Port State Control, IRS is to be immediately notified by the owner / operator for arranging attendance by a Surveyor.

2.2 Application of Rules

2.2.1 Unless directed otherwise by IRS, no new Regulations or amendments to the Rules relating to the character of classification or class notation is to be applied to the existing vessels.

2.2.2 Unless directed otherwise by IRS, no new Rules and Regulations or amendments to the existing Rules & Regulations become applicable within 6 months after the date of issue.

2.3 Scope of classification

2.3.1 Classification covers ship's hull, appendages and machinery including electrical systems to the extent as specified in these Rules & Regulations. Classification does not guarantee the design or performance of a vessel except for those aspects covered by the rule requirements and subject to the conditions of operation of the vessel mentioned in 2.1.2.

2.3.2 On application by Builder or Owner, certain installation, e.g. refrigerating machinery may be classed by IRS.

2.4 Interpretations of the Rules

2.4.1 The correct interpretation of the requirements contained in the Rules and other Regulations is the sole responsibility and at the sole discretion of IRS.

2.5 Definitions

2.5.1 **Clear water** : Water having sufficient depth to permit the normal development of wind generated waves.

2.5.2 **Fetch** : The extent of clear water across which a wind has blown before reaching the ship.

2.5.3 **Sheltered water** : Water where the fetch is six nautical miles or less.

2.5.4 **Reasonable weather** : Reasonable weather is assumed to exclude winds exceeding Beaufort force six associated with sea states resulting in green water being frequently taken on board the ship's deck. However it is realised that this is largely a matter of judgment and good seamanship and can vary for particular ships.

2.5.5 **Type notation** : A notation indicating that the ship has been designed and constructed with applicable Rules to that type of ship, e.g. "Bulk Carrier", "Oil Tanker", etc.

2.5.6 **Cargo notation** : A notation indicating that the ship has been designed, modified or arranged to carry one or more particular cargoes, e.g. "Phosphoric Acid". Ships with one or more particular cargo notations are not thereby prevented from carrying other cargoes for which they are suitable.

2.5.7 **Special feature notation** : A notation indicating that the ship incorporates special features which significantly affect the design, e.g. "movable decks".

2.5.8 **Service restriction notation** : A notation indicating that a ship has been classed on the understanding that it will be operated only in suitable areas or conditions which have been agreed to by IRS e.g. "Sheltered Water Service".

2.6 Character of classification

2.6.1 The following Characters and symbols are assigned by IRS to indicate classification of Steel Ships. (For explanation of abbreviations, see Appendix I).

2.6.2 **Character SUL** assigned to sea-going vessels indicates that the hull and its appendages and equipment (i.e. anchors, chain cable and hawsers) meet the Rule requirements for assignment of this Character of Class.

Guidance Note : Appendages to the hull referred to in 2.6.2, 2.6.3 and 2.6.4 means the rudder & rudder stock, rudder horn, sole pieces, propeller nozzles, shaft brackets, skeg etc. which are covered by the rule requirements.

2.6.3 **Character SU-** assigned to sea-going vessels indicates that the hull and its appendages meet the Rule requirements but equipment (i.e. anchors, chain cable and hawsers) is not supplied or maintained as per the relevant Rules but is considered by IRS to be acceptable for particular service.

2.6.4 **Character SU** assigned to sea-going vessels indicates that the hull and its appendages meet the Rule requirements but where special consideration has been given for reason of particular purpose of service and normal equipment may be unnecessary. In such cases letter 'L' is omitted from the Character SUL.

2.6.5 **Character IY** assigned to self-propelled seagoing vessels indicates that the machinery meets the Rule requirements for assignment of this Character of Class.

2.6.6 **The distinguishing mark** 卐 inserted before a Character of Class (SUL, SU-, SU, IY as appropriate) is assigned to new ships where the hull and its appendages, equipment and the machinery, as appropriate, are constructed under special survey of IRS in compliance with the Rules to the satisfaction of IRS.

2.7 Class notations - Hull

2.7.1 When requested by an Owner and agreed to by IRS or when considered necessary by IRS, a class notation will be appended to the character of classification. This class notation will consist of one of, or a combination of - a type notation, a cargo notation, a special duties notation, a special features notation and/or a service restriction notation, e.g. 卐 SUL CHEMICAL TANKER, "Sulphuric Acid", ESP, "Indian Coastal Service".

2.7.2 Details of the ship types and additional class notations are given in Appendix 1 and applicable Chapters in Pt.5 of the Rules.

2.7.3 Service restriction notation will generally be assigned in one of the forms given below, but this does not preclude the Owners or Shipbuilders from requesting special consideration for other forms of restrictions.

a) Sheltered Water Service : Service in sheltered water adjacent to sand banks, reefs, breakwaters or other coastal features, and in sheltered water between islands. The geographical limits will form part of the Class Notation.

b) Restricted Water Service : Service in sheltered waters and also for short distances (generally less than 15 nautical miles) beyond sheltered waters in 'reasonable weather'. The geographical limits will form part of the Class Notation.

c) Specified Coastal Service : Service along a coast, during the course of which the vessel does not go more than 20 nautical miles from the nearest land and may cross gulfs or similar features recognised by the local Administration as a part of the coastal service. The geographical limits will form part of the Class Notation, e.g. "Indian Coastal Service".

d) Specified Route Service : Service between two or more points or other geographical features which will form part of the Class Notation.

e) Specified Operating Area Service : Service within one or more geographical area(s) which will form part of the Class Notation.

2.8 Class notations - Machinery

2.8.1 The class notations that may be assigned by IRS are given in Appendix 1. IRS may prescribe additional notations as found necessary / expedient from time to time.

2.9 Materials, components, equipment and machinery

2.9.1 The materials used in the construction of hull and machinery intended for classification, or in the repair of ships already classed, are to be of good quality and free from defects and are to be tested in accordance with the relevant Rules. The steel is to be manufactured by an approved process at works recognized by IRS. Alternatively, tests to the satisfaction of IRS will be required to demonstrate the suitability of the steel.

Consideration may be given by IRS to accept the works approved by IACS Member Societies with whom IRS currently has Cooperation Agreements for this purpose.

2.9.2 Certification of materials, components, equipment and machinery is carried out on basis of the following, considering IRS and/or IMO requirements, as applicable:

a) Type approval carried out by IRS.

b) Unit certification by IRS.

c) Alternative Certification Scheme by IRS (see Section 4).

d) Mutual recognition of certificates, if type approved by an IACS Member Society or European Union recognized organization based on commonly agreed design requirements between IRS and the recognized organization.

2.10 Request for surveys

2.10.1 It is the responsibility of the Builders or Owners, as applicable, to inform the Surveyors of IRS in the port at which the surveys for supervision during new construction or ships in service are to be undertaken and to ensure that all surveys for issue of class certificate for new construction, and maintenance of class for ships in service are carried out.

2.11 Repairs

2.11.1 Any repairs to the hull, machinery and equipment either as a result of damage or wear and tear which are required for the maintenance of ship's class are to be carried out under the inspection of and to the satisfaction of the Surveyors.

2.11.2 Where a vessel is damaged to an extent resulting in towage outside port limits, it shall be the Owners' responsibility to notify IRS at the first practicable opportunity.

2.11.3 Where such repairs are effected at a port where there is no Surveyor of IRS, the ship is to be surveyed by one of its Surveyors at the earliest opportunity.

2.11.4 Where repairs to hull, machinery or equipment, which affect or may affect classification, are to be carried out by a riding crew, they are to be planned in advance. A complete repair procedure including the extent of proposed repairs and the need for Surveyor's attendance during the voyage is to be submitted to and agreed upon by the Surveyor reasonably in advance. Failure to notify IRS, in advance of the repairs, may result in suspension of the vessel's class.

Where in any emergency circumstance, emergency repairs are to be effected immediately, the repairs should be documented in the ship's log and submitted thereafter to IRS for use in determining further survey requirements.

2.12 Alterations

2.12.1 Any alterations proposed to be carried out to approved scantlings and arrangements of the hull, machinery or equipment are to meet with the approval of IRS and for this purpose plans and technical particulars are to be submitted for approval in advance. Such approved alterations are to be carried out under the inspection of, and to the satisfaction of, the Surveyors. If such alterations are carried out on items which may affect the classification of the ship without informing IRS, the class of the vessel will be liable to be suspended except in the case of emergency repairs mentioned in 2.11.4.

2.13 Classification of new constructions

2.13.1 The request for classification of new constructions is to be submitted to IRS by the shipyard or shipowner in the form provided by IRS. The request is to include complete details regarding class notation and statutory certificates required, where applicable.

The IRS Rules in force on the date of contract for construction of the vessel (See 2.14) will be applicable for classification, in general. However, statutory requirements coming into force after the date of contract for construction may have to be complied with if they become applicable based on any other criteria such as the date on which vessel is constructed (keel laid).

2.13.2 Where orders for major machinery and equipment are placed on manufacturer or suppliers, IRS will have to be informed. Responsibility for compliance with IRS Rules and Regulations shall be with the manufacturers/suppliers.

Where relevant, the date of application for certification of specific major machinery will also be considered in addition to the date of contract for construction of the vessel, for determining the applicable rules for such machinery.

2.13.3 Plans and particulars as specified in the Rules will have to be submitted to IRS in triplicate sufficiently in advance of commencement of construction. One copy with stamp of approval will be returned. Any deviation from approved drawings will require to be approved by IRS prior to execution of work.

IRS reserves the right to request for additional plans, information or particulars to be submitted.

Where it is proposed to use existing previously approved plans for a new contract, written application is to be made to IRS.

Approval of plans and calculations by IRS does not relieve the Builders of their responsibility for the design, construction and installation of the various parts, nor does it absolve the Builders from their duty of carrying out any alterations or additions to the various parts on board deemed necessary by IRS during construction or installation on board or trials.

2.13.4 IRS will assess the production facilities and procedures of the shipyard and other manufacturers as to whether they meet the requirements of the construction Rules.

Review of the construction facilities prior to any steel work or construction shall be carried out under the following circumstances:

a) Where IRS has none or no recent experience of the construction facilities – typically after a one year lapse – or when significant new infrastructure has been added.

b) Where there has been a significant management or personnel re-structuring having an impact on the ship construction process, or

c) Where the shipbuilder contracts to construct a vessel of a different type or substantially different in design.

2.13.5 During construction of a vessel, IRS will ensure by surveys that parts of hull and machinery requiring approval have been constructed in compliance with approved drawings, all required tests and trials are performed satisfactorily, workmanship is in compliance with current engineering practices and welded parts are produced by qualified welders.

2.13.6 All hull, machinery and electrical installations will be subjected to operational trials in the presence of IRS Surveyor.

2.13.7 On completion of the ship copies of as fitted plans showing the ship as built, essential certificates and records, loading manual etc. are to be submitted by the Builder generally prior to issuance of the Interim Certificate of Class.

2.13.8 For each new construction the shipbuilder is required to prepare and deliver a ship construction file containing documents / plans / manuals etc. for facilitating the future inspection of survey, repair and maintenance as detailed in Pt.3, Ch.1, Sec.3. Some of these documents may be directly supplied by other parties e.g. shipowner, for inclusion in the ship construction file. The ship construction file is to be maintained onboard each ship.

2.14 Date of contract for construction

2.14.1 The date of “contract for construction” of a vessel is the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. This date and the construction numbers (i.e. hull numbers) of all the vessels included in the contract are to be declared to IRS by the party applying for the assignment of class to a new building.

2.14.2 The date of “contract for construction” of a series of vessels, including specified optional vessels for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.

For the purpose of this requirement, vessels built under a single contract for construction are considered a “series of vessels” if they are built to the same approved plans for classification purposes. However, vessels within a series may have design alterations from the original design provided:

a) Such alterations do not affect matters related to classification, or

b) If the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to IRS for approval.

The optional vessels will be considered part of the same series of vessels if the option is exercised not later than 1 year after the contract to build the series was signed.

2.14.3 If a contract for construction is later amended to include additional vessels or additional options, the date of “contract for construction” for such vessels is the date on which the amendment to the contract, is signed between the prospective owner and the shipbuilder. The amendment to the contract is to be considered as a “new contract” to which 2.14.1 and 2.14.2 above apply.

2.14.4 If a contract for construction is amended to change the ship type, the date of “contract for construction” of this modified vessel, or vessels, is the date on which revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder.

2.15 Date of build

2.15.1 The date of completion of the special survey inspection will normally be taken as the date of build to be entered in the Register Book.

Where there is a substantial delay between completion of construction survey and the ship commencing service, the date of commissioning may be specified on the classification certificate.

When modifications are carried out on a ship, the initial date of build remains assigned to the ship.

2.15.2 When a complete replacement or addition of a major portion of the ship (e.g. fwd.section, midship section or aft section) is involved, the following applies:

- Date of build assigned to each portion of the ship will be indicated on the classification certificate, and the date of modification will be indicated in the Register Book.

- Survey requirements shall be based on the date of build associated with each major portion of the ship.

2.16 Appeal from Surveyors' recommendations

2.16.1 If the recommendations of the Surveyors are considered in any case to be unnecessary or unreasonable, appeal may be made to IRS, who may direct a special examination to be held.

2.17 Certificates

2.17.1 Certificates of Class will be issued to Builders or Owners when the required reports on completion of Special Surveys of new ships or of existing ships submitted for classification have been received from the Surveyors and approved by IRS.

2.17.2 Certificates of class maintenance in respect of completed periodical special surveys of hull and machinery will also be issued to Owners.

2.17.3 The Surveyors are permitted to issue Interim Certificates to enable a ship, classed with IRS, to proceed on her voyage provided that, in their opinion, she is in a fit and efficient condition. Such Certificates will contain Surveyors' recommendations for continuance of Class, but in all cases are subject to confirmation by IRS.

2.17.4 Individual Certificates can also be issued for propelling machinery, boilers, equipments and fittings which have been manufactured under IRS Survey and in accordance with these Regulations.

2.18 Suspension, withdrawal and deletion of class

2.18.1 Suspension

2.18.1.1 The class of a vessel will be automatically suspended from the expiry date of the Certificate of Class or by the expiry date of any extension granted, if the special survey has not been completed by the due date and an extension (See Ch.2, 1.11) has not been agreed to, or the vessel is not under attendance by the Surveyor with a view to complete the surveys prior to resuming service.

2.18.1.2 The class of a vessel will also be automatically suspended if the annual, intermediate survey become overdue. (See Pt.1 Ch.2, Table 1.1.1 for due dates and window period).

2.18.1.3 When the surveys relating to specific additional notations of hull or equipment or machinery have not been complied with and thereby the ship is not entitled to retain that notation, then the specific notation will be suspended till the related surveys are completed.

2.18.1.4 The class of a vessel will be subject to a suspension procedure if an item of continuous survey is overdue at the time of annual survey, unless the item is dealt with or postponed by agreement.

2.18.1.5 The class of the vessel will also be subject to a suspension procedure if recommendations and/or conditions of class are not dealt with by the due date or postponed by agreement, by the due date.

2.18.1.6 The class of a ship is liable to be withheld or, if already granted, may be withdrawn in case of any non-payment of fees or expenses chargeable for the service rendered.

2.18.1.7 Where any ship proceeds to sea with less freeboard than that approved by IRS or when the freeboard marks are placed higher on the ship's sides than the position assigned or approved by IRS, the ship's class will be suspended.

2.18.1.8 When it is found that a ship is being operated in a manner contrary to that agreed at the time of classification, or is being operated in conditions or in areas more onerous than those agreed, the class will be suspended.

2.18.1.9 The class of a vessel will be liable to be suspended if the Owner fails to notify IRS of any damage to the ship‘s hull, machinery or equipment, which may adversely affect classification of the vessel or subsequently fails to arrange for the survey as may be advised by IRS.

2.18.1.10 The class of a vessel will be suspended after a major casualty to the ship, such as grounding, sinking or breaking up, if the Owner is unable to arrange for the ship’s survey by IRS and commence repairs within a reasonable period of the occurrence of the casualty, unless otherwise agreed to with IRS.

2.18.1.11 Vessels laid up in accordance with the Rules prior to surveys becoming overdue will not be suspended when surveys addressed above become overdue.

However, ships which are laid up after being suspended as a result of surveys becoming overdue, will remain suspended until the overdue surveys are completed.

2.18.1.12 When a vessel is intended for a demolition voyage with any periodical survey overdue, the vessel's class will not be suspended till completion of a single direct ballast voyage from the lay up or final discharge port to the demolition yard.

2.18.1.13 Force Majeure : If, due to circumstances defined in Chapter 2, 1.11.3, the vessel is in a port where the overdue surveys cannot be completed at the expiry of the periods allowed above, IRS may allow the vessel to sail, in class, directly to an agreed discharge port, and if necessary, thereafter in ballast, to an agreed port at which the survey will be completed, provided:

a) Re-examination of the ship's record is carried out by IRS,

b) IRS carries out the due and/or overdue surveys and examination of Recommendations / Conditions of Class at the first port of call when there is an unforeseen inability of IRS to attend the vessel in the present port, and

c) IRS is satisfied that the vessel is in condition to sail for one trip to a discharge port and subsequent ballast voyage to a repair facility if necessary (where there is unforeseen inability of IRS to attend the vessel in the present port, the master is to confirm that the ship is in condition to sail to the nearest port of call).

The scope of the overdue surveys will be based on the survey requirements applicable to the vessel at the original due date and not based on the age of the vessel when the survey is carried out. Such surveys will be credited from the date originally due.

If class has already been automatically suspended in such cases, it may be reinstated subject to the conditions prescribed above.

2.18.1.14 When a vessel is intended for a single voyage from laid-up position to repair yard with any periodical survey overdue, the vessel's class suspension may be held in abeyance and consideration may be given to allow the vessel to proceed on a single direct ballast voyage from the site of lay up to the repair yard, upon agreement with the Flag Administration, provided IRS finds the vessel in satisfactory condition after surveys, the extent of which are to be based on surveys overdue and duration of lay-up. A short-term Class Certificate with conditions for the intended voyage may be issued. This is not applicable to vessels whose class was already suspended prior to being laid-up.

2.18.1.15 Classification will be reinstated upon satisfactory completion of overdue survey. The scope of the overdue surveys will be based on the survey requirements applicable to the vessel at the original due date and not based on the age of the vessel when the survey is carried out. Such surveys will be credited from the date originally due. Such surveys will be credited from the date originally due. However, the vessel will remain dis-classed from the date of suspension until the date class is reinstated.

2.18.1.16 The Owners and the Flag State, where applicable, would be informed in writing, of the suspension and reinstatement of Classification.

2.18.2 Withdrawal

2.18.2.1 Ship's class will be withdrawn, at the end of six months of suspension, if the Owner has not commenced any action to reinstate the ship's class. A longer suspension period may be granted when the vessel is not trading or in cases of lay-up awaiting attendance for reinstatement or disposition, in the event of a casualty.

2.18.2.2 When the class of a ship holding IRS class, is withdrawn by IRS in consequence of a request from the Owners, the notation "Class withdrawn at Owners' request" (with date) will be made in the subsequent reprints of the Register Of Ships. This entry will continue till the ship's class is reinstated or deleted.

2.18.2.3 When the Regulations as regards surveys on the hull or equipment or machinery have not been complied with and the ship thereby is not entitled to retain her class, the class will be withdrawn and the notation "Class withdrawn" (with date) will be made in the subsequent reprints of the Register Of Ships. This entry will continue till the ship's class is reinstated or deleted.

2.18.2.4 The withdrawal of a vessel will be confirmed in writing to the Owner and the Flag State, where applicable.

2.18.3 Deletion of Class

2.18.3.1 A ship will be considered to “cease to exist” when it is destroyed by scrapping or by sinking to unsalvageable depths or abandoned by the owner.

2.18.3.2 A ship can also be considered to “cease to exist” when it is broken up either by grounding or due to structural failure or due to actions of war or sabotage.

2.18.3.3 Ship’s class will be deleted when it ceases to exist.

2.19 Reclassification of ships

2.19.1 When Owners request for reclassification of a ship for which the class previously assigned has been withdrawn, IRS will require a Special Survey for Reclassification to be held by the Surveyors. The extent of the survey will depend upon the age of the ship and the circumstances of each case.

2.19.2 If the ship is found or placed in good and efficient condition in accordance with the requirements of the Rules and Regulations at the Special Survey for Reclassification, IRS may decide to reinstate her original class or assign such other class as considered appropriate.

2.19.3 The date of reclassification will appear in the supplement to the Register Of Ships and the subsequent issue of Register Of Ships.

2.20 Condition improvement program

2.20.1 The Condition Improvement Program (CIP) of IRS classed ships is aimed at improving fleet quality and safety and reducing the risk of Port State Control detentions.

Under this program vessels requiring special attention are identified based on multiple risk criteria and study of the recent history of the vessel such as survey status, conditions of class, recommendations, detentions etc. and the shipowner so informed.

2.20.2 Vessels identified for condition improvement would be subject to additional surveys over and above the normal classification surveys. For this purpose, surveyors are to be given necessary access to the ship for identification of deficiencies and recommendation of repairs. Deficiencies requiring immediate attention as indicated by the Surveyor are to be repaired promptly and thoroughly.

2.21 Transparency of classification and statutory information

2.21.1 The classification and statutory information which may be released to Shipowners, Flag State, Port state, Insurance company and Shipyards as relevant and the conditions for their release are indicated in Table 2.21.1. For oil tankers and bulk carriers subject to SOLAS Chapter II-1, Part A-1, Regulation 3-10, refer to IRS Rules for Bulk Carriers and Oil Tankers, Volume 1, Part 1, Chapter 1.

Table 2.21.1 : Transparency of information

		Information available to:				
	Information in Question	**Owners**	**Flag State**	**Port State**	**Insurance Company***	**Ship Yards**
1.	**Class Societies Standing Documents:**					
	Rules and Guidelines (Class and statutory requirements)	1	1	1	1	1
	Instructions to Surveyors		1			
	Quality Manual	1	1	1	1	1
	Register Book	1	1	1	1	1
2.	**Ship Related Information:**					
A.	**New Buildings**					
	Approved Drawings	6	1			7
	Formal Approval Letters	1				7
	Certificates of Important Equipment	2				7
B.	**Ships in Operation:**					
	Date (month and year) of all class surveys	7	1	1	1	
	Expiry Date of Class Certificate	7	7	1	1	
	Certificates/Reports	7	1	6	5	
	Overdue Surveys	7	7	1	1	
	Text of Conditions of Class/Recommendations	7	1	1	5	
	Text of Overdue Conditions of Class/Recommendations	7	1	1	1	
	Executive Hull Summary	7	3	3	3	
	Statutory Services					
	Due Dates of Statutory Surveys	7	7	1	1	
	Expiry Date of Statutory Certificates	7	7	1	1	
	Registered Statutory Recommendations	7	7	1	5**	
	Overdue Statutory Recommendations	7	7	1	1**	
3.	**Other Information:**					
	Correspondence File with Yard and/or Owner	6	6		5&6	
	Audit of Class Societies QA System	4	4	4	4	
	Class Transfer Reporting	7	7	7	7	
	Class Withdrawal Information	7	7	7	7	
*	Insurance Company means P&I Clubs and Hull Underwriters					
**	Unless prevented by the agreement with the Flag State					
KEY:						
1.	Available upon request					
2.	At delivery of the ship by Shipyard					
3.	Available under visit on board					
4.	Result of audit available on request					
5.	When accepted by Owners – or through special clause in insurance contract					
6.	When accepted by Owner (Master) or Shipyard as applicable					
7.	Automatically available					

Section 3

Classification of Ships not Built under the Survey of Indian Register of Shipping

3.1 General procedure for classification of ships not built under survey of IRS

3.1.1 Plans of hull and machinery in duplicate, together with torsional vibration calculations, where applicable, as specified in 3.2.5 are to be submitted for approval. It is preferable to have the plans approved before the classification survey is commenced.

3.1.2 Full special classification surveys would require to be carried out by IRS Surveyors in order to satisfy themselves regarding the workmanship and condition of the ship and to verify the approved scantlings and arrangements. The scope of these surveys may, however, be modified in the case of vessels built under the Special Survey and holding valid certificates of class of established classification societies or equivalent, if prior to commencement of survey by IRS, documentary evidence of all hull and machinery classification surveys held by the other society subsequent to last special survey carried out by them could be produced. In such cases, a special survey notation will not be assigned in conjunction with the classification survey. The next special survey therefore would become due five years from the special survey held by the other society and not five years from classification with IRS.

In cases of transfer of class from another society to single class of IRS, the interim certificate of class or any other documents enabling the ship to trade, can be issued :

a) In case of vessels less than 15 years of age

   – only after IRS has completed all overdue surveys and overdue recommendations / conditions of class issued earlier, as specified to the Owner by the previous society.

b) In case of vessels 15 years of age and over

   – only after the previous society has completed all overdue surveys and all overdue recommendations / conditions of class issued earlier.

3.1.3 For vessels not built under survey of IRS but subsequently taken in class with the above procedure, the mark signifying the survey during construction will be omitted.

3.1.4 Once a vessel has been taken into IRS class, periodical surveys are subsequently to be held as per these rules.

3.2 Plans and data to be furnished as required in 3.1.1

3.2.1 Plans of hull and equipment showing the main scantlings and arrangements of the actual ship and any proposed alterations are to be submitted for approval. These should normally comprise of the following plans:

For information

- General arrangement
- Capacity plan
- Hydrostatic Curves
- Loading Manual
- Loading Instrument Details
- Lightweight Distribution

For approval

- Midship section
- Longitudinal section and decks
- Shell expansion plan
- Transverse Bulkheads
- Fore body
- Aft body
- Sternframe
- Rudder and Rudder Stock
- Hatch Covers

- Fire detection, fighting and extinction and such other plans as may be requested.

3.2.2 It would normally be expected that particulars of the process of manufacture and testing of material of construction are furnished. Consideration will however be given to waiving this where such particulars are not readily available, provided it can be established that the relevant vessel has been originally built under special survey of an established classification society and continues to be so classed with an established classification society. In the case of vessels which have been originally built under the special survey of an established classification society but subsequently not maintaining class, it should additionally be possible to reasonably ascertain that no changes that would significantly affect the material specifications have taken place.

3.2.3 Following machinery plans together with the particulars of the materials used in the construction of the boilers, air receivers and important forgings should be furnished:

For information

- General machinery lay-out

For approval

- Thrust, intermediate and propeller shafting
- Propeller
- Main engines, propulsion gears and clutch systems (or manufacturer make, model and rating information)
- For steam turbine engines, main boilers, superheaters and economisers (or manufacturer make, model and rating information) and steam piping
- Bilge and ballast piping system
- Wiring diagram
- Steering gear systems, piping and arrangements and steering gear manufacturer make and model information
- Additional plans for oil tankers
    - Pumping arrangements at the forward and after ends and drainage of cofferdams and pump rooms
    - General arrangement of cargo piping in tanks and on decks
- Additional plans for vessels with Unattended Machinery Spaces
    - Description and/or block diagram of method of operation of the control system
    - Line diagrams of the control system for :

      main propelling machinery and essential auxiliaries

      bilge level systems

      cargo pumping for tankers

      boiler controls

      fire detection

      fire prevention, including details in way of fuel oil pressure pipes

      overall alarm system including test schedule
- Additional plans for vessels with Ice Class notations:
    - Plans for flexible couplings and/or torque limiting shafting devices in the propulsion line shafting (or manufacturer make, model and rating information)

3.2.4 Calculations of torsional vibration characteristics of the main propelling machinery are to be furnished specially for ships which have been in service for less than about 2 years.

3.2.5 In addition to the requirements of 3.2.1 to 3.2.4, additional plans would require to be submitted in accordance with applicable Chapters of Pt.5 of the Rules for vessels with additional class notations.

Section 4

Alternative Certification Scheme based upon Quality Management Systems

4.1 General

4.1.1 Alternative Certification Scheme (ACS) is a certification scheme involving a manufacturer (and associated sub-suppliers, if needed) in the inspection, testing and certification of the manufacturer's products.

4.1.2 An ACS will clarify:

- The extent of the required inspection and testing;

- To which extent and under which conditions the manufacturer may perform all or parts of the required inspection and testing without the presence of a Surveyor from IRS when an IRS Certificate is required.

4.1.3 The extent to which the manufacturer is given permission to carry out inspections and testing without the presence of a Surveyor would be agreed on a case by case basis, e.g. for a specific product production line or for specific parts.

4.2 Scope

4.2.1 An ACS may be arranged with product manufacturers and/ or sub-suppliers.

4.2.2 An ACS with a manufacturer would define the handling of subcontracted parts (those that require IRS or work certificates or in any other way are addressed in the Rules). The sub-supplier may be included in the ACS of the manufacturer or have his own ACS or deliver parts that are inspected and certified by the IRS.

4.2.3 An ACS that permits the manufacturer to carry out all or parts of required inspection and testing without the presence of a Surveyor may be arranged in two versions with regard to traceability:

- The ACS describes inspection, testing and certification additional to the manufacturer's standard quality control procedures in order to meet the Rules. The components are to be stamped with a special stamp supplied by IRS or identified as required by IRS.

- The manufacturer has a standard quality control that covers all required inspection, testing and certification in compliance with the Rules. Traceability and the required type of product document for components or products will be defined in the ACS.

4.3 Conditions for approval

4.3.1 The conditions for the manufacturer to be granted the permission to carry out inspection and testing without the presence of a Surveyor are as follows:

- The manufacturer has an implemented Quality System according to a national or international standard (like ISO 9000 series of standards) approved by an accredited certification body or recognized by IRS.

- The manufacturer has a quality control system, current drawings, and Rules and standards that cover the product to be certified.

- The inspection and testing required by the Rules are either standard procedures in the Quality System and recognized by IRS or specified in detail in the ACS.

- The manufacturer is to demonstrate that the firm has experience consistent with technology and complexity of the product for which approval is sought and that firm's products have been of a consistently high standard.

- IRS would initially ascertain the manufacturer's compliance with the ACS requirements by verifying the required product and process approvals and performing an initial audit. Follow-up and renewal audits would be conducted by IRS on a regular basis to verify that conditions of the ACS are continuously maintained by the manufacturer.

- If work certificates (W) or test reports (TR) are found not to fulfill the standards agreed with IRS, the component may not be accepted.

- The agreed ACS may be suspended or cancelled when/ if found justified by IRS.

- IRS may carry out unscheduled inspections at the manufacturer and/or subcontractor at its own discretion.

- The manufacturers (and designers, if producing under license) are to commit themselves to involve IRS when changes to the design, manufacturing process or testing are made as well as when any major production problems or any major product delivery problems have occurred.

4.4 Information to be submitted

4.4.1 For admission to an alternative certification scheme for a product, the manufacturer is to submit an application enclosing the following documentation/ information:

- Description of the products for which certification is required including, where applicable, model or type number;

- Applicable plans, details of materials used and procedures relevant to the manufacturing process;

- An outline description of all important manufacturing equipment and plant;

- A list of suppliers of materials with an indication of their class approval (as far as required by the Rules) and the type of material certification in each case;

- The list of main components of the product, including certificates.

- Existing class approvals of the manufacturer's products as far as required;

- Quality control plans relevant to the products and relevant components to be certified through the alternative certification scheme. Said plans are to detail the inspections and tests required by the Rules with an indication of which inspections and tests are delegated to the manufacturer and which are to be done in the presence of an IRS Surveyor.

- The procedures relevant to the quality control and inspections, their methods, frequency and certification;

- The quality system details;

- The system used for identification and traceability;

- List of nominated personnel for:

  - Marking/stamping of products;

  - Tests and Inspection (responsible);

  - Provision of data and information (e.g. declaration of conformity, test reports etc.).

- Any other additional documents that IRS may require in order to evaluate the manufacturing processes and product quality control.

4.5 Approval and maintenance of approval

4.5.1 After receipt and appraisal of the information required by 4.4, an initial audit of the Works would be carried out by the Surveyors. This audit is to verify that the manufacture of the product and the relevant controls are performed in accordance with the documents submitted and are in compliance with the requirements laid down in the Rules.

4.5.2 The ACS validity is for 5 years. At least one intermediate audit would be carried out by IRS during the validity of the ACS. Annual surveillance audits would be carried out as necessary, depending upon the complexity of the products and experience with the firms. The ACS may be renewed subject to an audit. The scope of the renewal audit would be as follows:

- verify the conditions of the ACS are still met;

- verify that the current products and processes are appropriately controlled.

4.5.3 A Quality Assurance Certificate would be issued by IRS on satisfactory completion of the initial/ renewal audit.

Appendix 1

Table of characters of class and type notations of IRS, their expanded form and significance

Abbreviation	Expanded Form	Significance
Characters of Class		
SUL	SARVOUTAM LANGER	Denotes vessels which are classed with Indian Register of Shipping where the hull and its appendages and equipment (i.e. anchors, chain cables, hawsers) meet the Rule requirements.
SU-	SARVOUTAM	Denotes vessels which are classed with IRS where the hull and its appendages meet the rule requirements but when the equipment of ship is not supplied or maintained as per the relevant Rules but is considered by IRS to be acceptable for particular service
SU	SARVOUTAM	Denotes vessels which are classed with IRS where the hull and its appendages meet the rule requirements but where for reason of their particular purpose or service normal equipment may be unnecessary
IY	INDIAN YANTRA	Denotes that for self propelled seagoing vessels, the machinery installation complies with the applicable requirements of Indian Register of Shipping
卐	SWASTIKA	This distinguishing mark inserted before a Character of Class is assigned to new ships where the hull and its appendages, equipment and the machinery as appropriate, are constructed under special survey of IRS in compliance with the Rules to the satisfaction of IRS
[ ]		When a Class Notation is enclosed within brackets, it indicates that applicable arrangements exist on board but the notation has been temporarily suspended
Class Notations - Hull		
Sheltered Water Service		Service in sheltered water adjacent to sand banks, reefs, breakwaters or other coastal features, and in sheltered water between islands
Restricted Water Service		Service in sheltered waters and also for short distances (generally less than 15 nautical miles) beyond sheltered waters in 'reasonable weather'
Specified Coastal Service		Service along a coast, during the course of which the vessel does not go more than 20 nautical miles from the nearest land and may cross gulfs or similar features recognised by the local Administration as a part of the coastal service. The geographical limits will form part of the Class Notation, e.g. "Indian Coastal Service"
Specified Route Service		Service between two or more points or other geographical features which will form part of the Class Notation
Specified Operating Area Service		Service within one or more geographical area(s) which will form part of the Class Notation

Abbreviation	Expanded Form	Significance
HAT(B)	HIMA ATITIVRA (B)	Denotes that the ship is strengthened for first year ice conditions in Northern Baltic in winter or areas of similar ice with condition equivalent to unbroken level ice with a maximum thickness of 1.0 metre
HT(B)	HIMA TIVRA (B)	Denotes that the ship is strengthened for first year ice conditions in Northern Baltic in winter or areas of similar ice with condition equivalent to unbroken level ice with a maximum thickness of 0.8 metre
HM(B)	HIMA MADHYAM (B)	Denotes that the ship is strengthened for first year ice conditions in Northern Baltic in winter or areas of similar ice with condition equivalent to unbroken level ice with a maximum thickness of 0.6 metre
Ha(B)	HIMA ALPA (B)	Denotes that the ship is strengthened for first year ice conditions in Northern Baltic in winter or areas of similar ice with condition equivalent to unbroken level ice with a maximum thickness of 0.4 metre
Ha	HIMA ALPA	Denotes that the ship is strengthened for light first year ice conditions in areas other than Northern Baltic
PC1	Polar Class 1	Denotes that the ship is strengthened for year-round operation in all polar waters according to Pt.5, Ch.32
PC2	Polar Class 2	Denotes that the ship is strengthened for year-round operation in moderate multi-year ice conditions according to Pt.5, Ch.32
PC3	Polar Class 3	Denotes that the ship is strengthened for year-round operation in second-year ice which may include multi-year ice inclusions according to Pt.5, Ch.32
PC4	Polar Class 4	Denotes that the ship is strengthened for year-round operation in thick first-year ice which may include old ice inclusions according to Pt.5, Ch.32
PC5	Polar Class 5	Denotes that the ship is strengthened for year-round operation in medium first-year ice which may include old ice inclusions according to Pt.5, Ch.32
PC6	Polar Class 6	Denotes that the ship is strengthened for summer / autumn operation in medium first-year ice which may include old ice inclusions according to Pt.5, Ch.32
PC7	Polar Class 7	Denotes that the ship is strengthened for summer / autumn operation in thin first-year ice which may include old ice inclusions according to Pt.5, Ch.32
ESP		Vessel complies with requirements of enhanced survey programme
STS	SAMATARANA STHIRATVA	Denotes that the ship complies with the requirements for survival capability (floatability in damaged condition) in accordance with Chapter 3 of IMO Resolution MSC 235(82)
"Strengthened for heavy cargoes"		This will be entered in the Register of Ships where the scantlings and arrangements have been approved for heavier cargo loadings in any hold filled up to the top of the hatch coaming with cargo at a stowage rate of ≤ 1 [m^3/tonne], when the draught in way of the hold is 80 per cent of the maximum permissible draught or more

Abbreviation	Expanded Form	Significance
"Hold(s) ...(to be specified)......... may be empty"		This will be entered in the Register of Ships when in association with the carriage of heavy cargoes, specified holds are permitted to be empty with the ship in the fully loaded condition
HELDK		This will be entered in the Register Of Ships for vessels with erected platforms or landing area designed for helicopter landings in accordance with applicable requirements of Part 5, Chapter 27 of the Rules
ETA	EMERGENCY TOWING ARRANGEMENT	Denotes that the ship is equipped with emergency towing arrangements in accordance with the requirements given in Part.5, Chapters 2, 3 or 4 of the Rules
Load Comp (1)	LOADING COMPUTER (1)	Denotes that the ship is equipped with a loading computer capable of ascertaining and comparing with the permissible limits, the hull girder loads in still water in any loading condition as required by Pt.3, Ch.5 and Pt.5, as applicable, of the Rules
Load Comp (2)	LOADING COMPUTER (2)	Denotes that in addition to the requirements for Load Comp (1) mentioned above, the ship's loading computer is capable of performing intact stability calculations for any loading condition to verify compliance with the applicable requirements indicated in Pt.3, Ch.1 of the Rules
Load Comp (3)	LOADING COMPUTER (3)	Denotes that in addition to the requirements for Load Comp (2) mentioned above, the ship's loading computer is capable of performing the stability calculations in damaged condition
Load Comp (4)	LOADING COMPUTER (4)	Denotes that in addition to the requirement for Load Comp (2) mentioned above, the ship's loading computer is capable of performing both stability and strength calculations in damaged condition
INWATER SURVEY		Denotes that the examination of the ship's bottom and related items may be carried out while the ship is afloat in accordance with the applicable requirements indicated in Pt.1, Ch.2, Sec.7.2
"For carriage of cement in bulk"		This will be entered in the Register of Ships for vessels which are designed and constructed solely for carriage of cement in bulk and the scantlings and arrangements have been approved accordingly
SPM	SINGLE POINT MOORING	Denotes that the vessel is fitted with standard arrangements for single point mooring as per Pt.5, Ch.28 of the Rules
DOUBLE HULL		When bulk carriers, oil tankers, oil or ore carriers and oil or bulk carriers are of double hull construction, in the entire cargo area (See Ch.2, Sec.1), the main class notations described above will be appended by notation 'DOUBLE HULL'

Abbreviation	Expanded Form	Significance
Class Notations - Machinery		
CCS	CENTRALIZED CONTROL STATION	Denotes that the propulsion and auxiliary machinery can be controlled and monitored with continuous supervision from a Centralized Control Station as detailed in Pt.4, Ch.7. It also denotes that the control engineering equipment has been arranged, installed and tested in accordance with Rules.
SYJ	SWACHALIT YANTRIK JAHAZ	Denotes that the ship can be operated with the machinery spaces unattended in accordance with the applicable requirements of Part 5, Chapter 22 of the Rules
HY	HIMIKAR YANTRA	Denotes that the refrigerated cargo installation of a ship complies with the applicable requirements of Part 5, Chapter 23 of the Rules
HY*	HIMIKAR YANTRA*	Denotes that the refrigerated cargo installation is capable of cooling down fruit in general or a catch of fish and complies with the applicable requirements of Part 5, Chapter 23 of the Rules
HY(LGC)	HIMIKAR YANTRA (LGC)	Denotes that the reliquefaction or refrigeration installation fitted on a classed liquefied gas carrier for cargo temperature and pressure control complies with the applicable requirements of Part 5, Chapter 4 of the Rules
NV	NIPRABHAV VASHPA	This notation is assigned to ships classed with Indian Register of Shipping intended for (i) carriage of oil in bulk or (ii) carriage of liquid chemicals in bulk. It denotes that the cargo spaces can be inerted by means of an inert gas system which has been approved, installed and tested in accordance with the relevant Rules
AGNI 1	AGNI SHAMAK	Denotes that the ship is equipped for early stage fire fighting and rescue operations close to structures including means for self protection of the vessel
AGNI 2		Denotes that the ship is equipped for continuous fighting of large fires and for cooling of structures on fire including means for self protection of the vessel
AGNI 3		Denotes that the ship is equipped for continuous fighting of large fires and for cooling of structures on fire and of greater capacity than for "AGNI 2"
DP (1)	DYNAMIC POSITIONING (1)	Denotes that the ship is fitted with automatic controls for position keeping as Pt.5, Ch.24 of the Rules
DP (2)	DYNAMIC POSITIONING (2)	Denotes that the ship is fitted with automatic controls of position keeping with automatic standby controls and redundancy in design and equipment as required by Pt.5, Ch.24 of the Rules
DP (3)	DYNAMIC POSITIONING (3)	Denotes that the ship is fitted with automatic controls for position keeping with automatic standby controls, redundancy in design and equipment and physical separation of components in different compartments as per Pt.5, Ch.24 of the Rules

Abbreviation	Expanded Form	Significance
IBS	Integrated Bridge System	The additional class notations 'IBS' will be assigned to ships fitted with an Integrated Bridge System in accordance with the requirements given in Pt.5, Ch.31. Integrated Bridge System allows simplified and centralized bridge operation of the main functions of navigation, manoeuvring and communication, as well as monitoring from the bridge of other functions such as: - Passage execution - Communication system - Monitoring of the machinery installation - Pollution monitoring - Monitoring of HVAC for passenger ships - Safety and security.
JUS	JALAJJAN UPAKARANA SAJJITA	Denotes that the ship is equipped with diving equipment
COW	CRUDE OIL WASHING	Denotes that the ship is equipped with crude oil washing system in accordance with Part 5, Chapter 2 of the Rules
PMS	PLANNED MAINTENANCE SYSTEM	Denotes that the machinery is subject to a system of planned maintenance and surveys as per Pt.1, Ch.2, Sec.14 of the Rules
Pollution Prevention Notations		
VCS1 VCS2	VAPOUR CONTROL SYSTEM	The additional notation VCS1 will be assigned to oil tankers, combination carriers (ore or oil/oil or bulk) and chemical tankers equipped with vapour control system meeting the requirements of IMO MSC/CIRC.585. The additional notation VCS2 will be assigned to oil tankers and chemical tankers equipped with vapour control system meeting the requirements of USCG's regulations CFR46 Part 39. The requirements for the assignment of this notation are given in Part 5, Chapter 29

<table>
<tr><th>Abbreviation</th><th>Expanded Form</th><th>Significance</th></tr>
<tr><td>CLEAN-SEA</td><td></td><td> The additional class notation CLEAN-SEA is assigned to ships provided with construction and procedural means to prevent pollution of sea. This is achieved by complying with the applicable requirements of Annexes I, II, III, IV, V of MARPOL Convention, as well as additional requirements related to prevention of sea pollution as follows:

Prevention of accidental pollution by locating fuel and lub.oil tanks above the double bottom and away from side shell.
Prevention of operational pollution by means of bilge water separation and filtering, holding tanks for treated sewage and grey water
Prevention of transfer of harmful organisms and pathogens in the ballast water
Prevention of pollution by tributyltin by means of TBT free antifouling paints
Prevention of pollution by solid garbage (resulting from the compacting device and incinerators) by means of proper storage of such waste

The requirements for the assignment of this notation are given in Part 5, Chapter 30 of Rules. </td></tr>
<tr><td>CLEAN-AIR</td><td></td><td> The additional class notation CLEAN-AIR is assigned to ships provided with construction and procedural means to prevent pollution of the air. This is achieved by complying with the applicable requirements of Annex VI of MARPOL convention as well as following additional requirements related to emissions to the air:

Prevention of air pollution by exhaust gas (NOx, SOx, etc.) by means of low emission engines
Use of low sulphur content fuels and incinerators
Use of refrigerants and fixed fire fighting means with zero ozone depleting potential and low global warming potential
Control of release of refrigerants to the atmosphere by means of leak detection and evacuation systems
Recovery of vapours emitted from cargo systems of ships carrying dangerous liquid cargoes in bulk

Note 1 : For ships with the service notation of oil tanker, oil or bulk carrier, ore or oil carrier, chemical tanker or liquefied gas carrier, the assignment of the notation VCS1 or VCS2 is a pre-requisite for assigning the notation CLEAN-AIR.
The requirements for the assignment of this notation are given in Part 5, Chapter 30 of Rules. </td></tr>
</table>

Abbreviation	Expanded Form	Significance
EP	Environmental Protection	The additional class notation EP is assigned to ships provided with equipment and procedural means to prevent pollution of the sea and of air. This is achieved by complying with the requirements of Annexes I to VI of MARPOL Convention and additional requirements relevant to ship's liquid, solid and gas releases as detailed in Part 5, Chapter 30 of Rules. Additionally the vessel should have developed an Environmental Management Plan considering the IMO requirements for recycling. Note 1 : For ships with the service notation of oil tanker, oil or bulk carrier, ore or oil carrier, chemical tanker or liquefied gas carrier, the assignment of the notation VCS1 or VCS2 is a prerequisite for assigning the notation Environment Protection – EP. The requirements for the assignment of this notation are given in Part 5, Chapter 30 of Rules.

Ship Type Notation

Ship Type Notation	Significance
BULK CARRIER	This notation will be assigned to ships designed primarily for the carriage of dry cargo in bulk and built in accordance with the applicable requirements of Part 5, Chapter 1 of the Rules for carriage of cargoes of density of at least 0.8 t/m^3
ORE CARRIER	This notation will be assigned to ships specially designed primarily to carry ore and built in accordance with applicable requirements of Part 5, Chapter 1 of the Rules
OIL TANKER	This notation will be assigned to tankers intended primarily to carry oil in bulk and built in accordance with applicable requirements of Part 5, Chapter 2 of the Rules. Where the scantlings and arrangements have been approved for the carriage of oil having a flash point of 60°C or above (closed cup test) or other liquid cargoes in bulk, the class notation will be suitably modified to show the nature of the cargo
ORE OR OIL CARRIER OIL OR BULK CARRIER	These notations will be assigned to combination carriers specially designed primarily to carry dry bulk cargoes (bulk carriers and ore carriers) and alternatively, oil in bulk, in accordance with Pt.5, Ch.2, Sec.12 of the Rules. In such ships, simultaneous carriage of dry bulk cargo and oil is prohibited.
CHEMICAL TANKER	This notation will be assigned to ships specially designed primarily to carry chemicals in bulk and built in accordance with applicable requirements of Part 5, Chapter 3 of the Rules
LIQUEFIED GAS CARRIER	This notation will be assigned to ships specially designed for the carriage of liquefied petroleum, natural or other gases and built in accordance with applicable requirements of Part 5, Chapter 4 of the Rules
CONTAINER SHIP	This notation will be assigned to vessels built for the exclusive carriage of containers in holds and on deck in accordance with the applicable requirements of Part 5, Chapter 5 of the Rules
PASSENGER SHIP	This notation will be assigned to vessels intended for carrying more than 12 passengers and built in accordance with Part 5, Chapter 6 of the Rules

Ship Type Notation	Significance
FERRY	This notation will be assigned to vessels intended for carriage of passengers and/or vehicles on regular scheduled service and built in accordance with Part 5, Chapter 6 of the Rules
Ro-Ro FERRY	This notation will be assigned to ferries intended for carriage of passengers, vehicles and cargo in pallet form or in containers and loaded/unloaded by wheeled vehicles and built in accordance with Part 5, Chapter 6 of the Rules
TUG	This notation will be assigned to all ships built in accordance with applicable requirements of Part 5, Chapter 7 of the Rules
ANCHOR HANDLING TUG	This notation will be assigned to tugs designed for anchor handling operations and built according to the requirements for this purpose given in Pt.5, Ch.7 and Pt.5, Ch.8 of the Rules.
SUPPLY VESSEL	This notation will be assigned to all ships built in accordance with applicable requirements of Part 5, Chapter 8 of the Rules
STERN TRAWLER	This notation will be assigned to ships built in accordance with applicable requirements of Part 5, Chapter 9 of the Rules and engaged in stern trawling
TRAWLER	This notation will be assigned to ships built in accordance with applicable requirements of Part 5, Chapter 9 of the Rules and engaged in side trawling
FISHING VESSEL	This notation will be assigned to ships built in accordance with applicable requirements of Part 5, Chapter 9 of the Rules and not equipped with trawling gear
DREDGER, HOPPER DREDGER, RECLAMATION CRAFT, HOPPER BARGE, SPLIT HOPPER BARGE	These notations will be assigned to self propelled or non self propelled vessels engaged in dredging or reclamation operation in accordance with applicable requirements of Part 5, Chapter 10 of the Rules
BARGE	This notation will be assigned to non self- propelled, manned or unmanned ships carrying dry cargo in cargo holds and built in accordance with applicable requirements of Part 5, Chapter 11 of the Rules. For special purpose vessels, the Notation will be suitably modified, e.g. Shipborne Barge
OIL BARGE	This notation will be assigned to non self- propelled, manned or unmanned ships intended to carry oil in bulk and built in accordance with the applicable requirements of Part 5, Chapters 2 & 11 of the Rules. Where the scantlings and arrangements have been approved by IRS for the carriage of oil having a flash point of 60°C or above (closed cup test), or for other liquid cargoes in bulk, the class notation affixed to the Character will be suitably modified to show the nature of the cargo (e.g. water barge, molasses barge, etc.)
PONTOON	This notation will be assigned to non self- propelled, manned or unmanned ships designed specifically for the carriage of non-perishable cargo or equipment on deck and built in accordance with the applicable requirements of Part 5, Chapter 11 of the Rules. For special purpose vessels, the Notation will be suitably modified, e.g. Crane Pontoon
FLOATING DOCK	This notation will be assigned to floating dry docks built in accordance with the applicable requirements of Part 5, Chapter 12 of the Rules.

Ship Type Notation	**Significance**
WELL STIMULATION VESSEL	This notation will be assigned to well stimulation vessels built in accordance with the applicable requirements of Part 5, Chapter 33.
OIL RECOVERY VESSEL	This notation will be assigned to oil recovery vessels built in accordance with the applicable requirements of Part 5, Chapter 34.

End of Chapter

Chapter 2

Periodical Surveys

Contents

Section 1

General Requirements

1.1 General

1.1.1 All vessels are to be subjected to Periodical Surveys for the purpose of maintenance of class. Survey notations and Survey intervals are given in Table 1.1.1 for main class Surveys. Where additional class notations have been assigned, Surveys are to be carried out at intervals given in Table 1.1.2.

1.1.2 Vessels with additional class notations for which there are no specific Survey requirements defined in this Chapter are to have the equipment and/or construction related to this additional class notation examined to the Surveyor's satisfaction at each Special Survey. However, at the time of Annual Surveys the continued effectiveness, of operational features, safety devices and control systems are to be verified.

1.1.3 Annual, intermediate and special surveys are to be held concurrently with the relevant statutory surveys under the various IMO conventions, in accordance with the Harmonised System of Survey and Certification of IMO.

1.1.4 Special consideration may be given in the application of relevant requirements of this chapter to commercial vessels owned or chartered by Governments, which are utilized in support of military operations or service.

Table 1.1.1 : Periodical survey intervals for class survey notations

(Any specific requirements of the flag Administration are also to be complied with)

Survey	Class survey notation	Survey interval in years
Hull : Special Survey	SSH	5
Hull : Continuous Survey	CSH	5^5
Machinery : Special Survey	SSM	5
Machinery : Continuous Survey	CSM	5
Intermediate Survey	IS	2 or 3^4
Annual Survey	AS	1^1
Docking Survey	DS	2.5^2
Shaft Survey Oil Lubricated Fresh Water Lubricated Closed Loop System Single Shaft Fresh Water Lubricated Open System Single Shaft Corrosion Protected or Corrosion Resistant Material Water Lubricated Open System Multiple Shaft, Water Lubricated Open System Single Shaft, Water Lubricated Open System	 SH (OL) SH (FW-C) SH (S-FW-O) SH (S-CP-O) SH (M-O) SH (S-O)	See Note 3, 7
Directional propellers, water jet units, or athwartship thrust propellers	DPROP	5^3
Main boilers	MBS	2.5^6
Auxiliary boilers	ABS	2.5^6
Thermal oil heating systems	TOH	2.5^6
Exhaust gas steam generators and economisers	EGES	2.5^6
Steam pipe survey 1st Survey 2nd and subsequent surveys	SPS	 10 5

Notes:

1	Survey may be carried out within 3 months on either side of the anniversary date.
2	At least 2 Surveys are to be carried out within any 5 year special survey cycle, but the interval between two consecutive surveys is not to exceed 3 years and one of these two docking surveys should coincide with the Special Survey. Proposals for alternative means for providing underwater inspection equivalent to drydocking survey would be considered by IRS as detailed in Sec.7. However, for vessels operating solely in fresh-water only one docking survey coinciding with the special survey need be carried out till special survey no. IV provided the interval between consecutive docking surveys does not exceed 5 years.
3	Upon request, IRS may extend the survey period to harmonise with docking survey and in accordance with the requirements of Section 11.
4	Survey may be carried out either at or between the second or third Annual Survey.
5	At the request of the Owner, IRS may agree that the special survey of the hull, for ships other than bulk carriers, oil tankers, combination carriers, chemical tankers, liquefied gas carriers and general dry cargo ships, be carried out on the continuous basis.
6	At least 2 surveys are to be carried out within any 5 year special survey cycle. The interval between two consecutive surveys is not to exceed 3 years.
7	See Tables 11.2.3 and 11.3.3 for survey intervals of closed and open systems respectively.

Table 1.1.2 : Periodical survey intervals for additional class notations

Survey of	Additional class notation / corresponding class survey notation	Survey interval in years
Planned Maintenance System of Machinery	**PMS**	
Annual Audit	AA(PMS)	1[3]
Diving system	**JUS**	
Annual Survey	AS(JUS)	1[1]
Special Survey	SS(JUS)	5
Cargo refrigerating plant	**HY**	
Annual Survey	AS(HY)	1[1]
Special Survey	SS(HY)	5
Continuous Survey	CS(HY)	5
Dynamic positioning system	DP(1), (2) and (3)	
Annual Survey	AS(DP)	1[1]
Special Survey	SS(DP)	5
External fire fighting	**AGNI 1, 2 & 3**	
Annual survey	AS(AGNI)	1[1]
Special survey	SS(AGNI)	5
Inert gas installation	**NV**	
Annual Survey	AS(NV)	1[1]
Special Survey	SS(NV)	5
Un-attended Machinery Spaces	**SYJ**	
Annual Survey	AS(SYJ)	1[1]
Special Survey	SS(SYJ)	5

Notes:

1 May be carried out within 3 months on either side of anniversary date.

2 Survey may be carried out either at or between the second or third annual survey.

3 To be carried out in conjunction with annual survey.

1.2 Definitions

1.2.1 A **Ballast tank** is a tank which is being used for the carriage of salt water ballast.

In the case of oil tankers and chemical tankers, combined cargo/ballast tanks which are used for the carriage of cargo or ballast water as a routine part of the vessel's operation, are to be treated as ballast tanks. Cargo tanks in which water may be carried only in exceptional cases as per MARPOL I/18(3), are to be treated as cargo tanks. In any case, when substantial corrosion is found in a tank used for both cargo and ballast, the tank is to be considered as a ballast tank for the purpose of application of survey requirements

In the case of bulk carriers, a space used for both cargo and salt water ballast is to be treated as a ballast tank for the purpose of application of survey requirements when substantial corrosion is found in that space. Further in the case of double skin bulk carrier a double side tank is to be considered as a separate tank even if it is in connection to either the topside tank or the hopper side tank.

1.2.2 A **Close-up survey** is a survey where the details of structural components are within the close visual inspection range of the Surveyor, i.e. normally within reach of hand.

1.2.3 An **Overall survey** is a survey intended to report on the overall condition of the hull structure and determine the extent of additional Close-up Surveys.

1.2.4 A **Transverse section** includes all longitudinal members such as plating, longitudinals and girders at the deck, side, bottom, inner bottom and hopper side plating, longitudinal bulkheads and bottom plating in top wing tanks. Where transversely framed, the transverse section is to include adjacent transverse stiffeners and their end connections.

1.2.5 **Representative spaces/tanks** are those which are expected to reflect the condition of other spaces/tanks of similar type and service and with similar corrosion prevention systems. When selecting Representative Spaces/Tanks account is be taken of the service and repair history onboard and identifiable Critical Structural Areas and/or Suspect Areas.

1.2.6 **Suspect areas** are locations showing Substantial Corrosion and/or considered by the Surveyor to be prone to rapid wastage.

1.2.7 **Critical structural areas** are locations which have been identified from calculations to require monitoring or from the service history of the subject ship or sister ships (if available) to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the ship.

1.2.8 **Substantial corrosion** is an extent of corrosion such that assessment of corrosion pattern indicates a wastage in excess of 75 per cent of allowable margins, but within acceptable limits.

For vessels built under the IACS Common Structural Rules, substantial corrosion is an extent of corrosion such that the assessment of the corrosion pattern indicates a gauged (or measured) thickness between t_{ren} + 0.5 [mm] and t_{ren}.

't_{ren}' is the renewal thickness, which is defined as the minimum allowable thickness [mm], below which renewal of structural members is to be carried out.

1.2.9 **Corrosion prevention system** is normally to be of a full hard protective coating. Hard protective coatings are to usually be epoxy coating or equivalent. Soft or semi-hard coatings are not acceptable. Other coating systems may be considered acceptable as alternatives provided they are applied and maintained in compliance with the manufacturer's specifications.

1.2.10 **Coating condition** is defined as follows :
GOOD - Condition with only minor spot rusting;
FAIR - Condition with local breakdown at edges and weld connections and/or light rusting over 20 per cent or more of areas under consideration, but less than as defined for POOR condition;
POOR - Condition with general breakdown of coating over 20 per cent or more of areas or hard scale at 10 per cent or more of areas under consideration.

1.2.11 **Cargo area** in case of oil tankers and chemical tankers is that part of the ship which contains cargo tanks, slop tanks and cargo/ballast pump rooms, cofferdams, ballast tanks and void spaces adjacent to cargo tanks and also deck areas throughout the entire length and breadth of the part of the ship over the above mentioned spaces.

In the case of liquefied gas carriers, cargo area is that part of the ship which contains the cargo containment system, cargo/ballast pump rooms and compressor rooms, cofferdams, ballast tanks and void spaces adjacent to the cargo containment spaces and also deck areas throughout the entire length and breadth of the part of the ship over the above mentioned spaces.

In the case of bulk carriers and general dry cargo ships, cargo area is that part of the ship which contains all cargo holds and adjacent areas including fuel tanks, cofferdams, ballast tanks and void spaces etc. within the longitudinal extent from the aft bulkhead of the aft-most cargo hold to the fwd bulkhead of the foremost cargo hold.

Note: The definitions for cargo area given above are applicable only for the purpose of identifying spaces for examination during hull surveys as required by this chapter of the Rules. For the purpose of design and construction requirements, the definitions given in respective chapters of Part 5 of the rules would apply.

1.2.12 **Spaces** are separate compartments including holds, tanks, cofferdams and void spaces bounding cargo holds, decks and the outer hull.

1.2.13 **A prompt and thorough repair** is a permanent repair completed at the time of survey to the satisfaction of the Surveyor, therein removing the need for the imposition of any associated condition of classification, or recommendation.

1.2.14 **Anniversary date** means the day and month of each year corresponding to the expiry date of the classification certificate.

1.2.15 **A Double Hull Oil Tanker** is a ship which is constructed primarily for the carriage of oil (See Pt.5, Ch.2, for list of oils) in bulk, which has the cargo tanks protected by a double hull which extends for the entire length of the cargo area, consisting of double sides and double bottom spaces for the carriage of water ballast or as void spaces.

1.2.16 For the purpose of application of these requirements, a '**double skin bulk carrier'** is a ship which is constructed generally with single deck, top side tanks, hopper side tanks & double bottom in cargo spaces and is intended primarily to carry dry cargo in bulk, including such types as ore carriers and combination carriers, in which all cargo holds are bounded by double-side skin (regardless of the width of the wing space).

1.2.17 'General dry cargo ship' means ships carrying solid cargoes other than:

- bulk carriers and ore carriers which are subject to the requirements of Sec.2;
- dedicated Container carriers;
- ro-ro cargo ships;
- refrigerated cargo ships;
- dedicated wood chip carriers;
- dedicated Cement carriers;
- livestock carriers;
- ships carrying exclusively deck cargo;
- General dry cargo ships of double skin construction, with double skin extending for the entire length of the cargo area and for the entire height of the cargo hold to the upper deck.

1.2.18 **Special consideration or specially considered** (in connection with close-up surveys and thickness measurements) means that sufficient close-up inspection and thickness measurements are to be taken to confirm the actual average condition of the structure under the coating.

1.2.19 **Air pipe heads** installed on the exposed decks are those extending above the freeboard deck or superstructure decks.

1.2.20 A **ro-ro Ship** is a ship which utilizes a loading ramp to enable wheeled vehicles to be rolled-on and rolled-off the ship,

1.2.21 **Pitting corrosion** is defined as scattered corrosion spots/areas with local material reductions which are greater than the general corrosion in the surrounding area.

1.2.22 **Edge corrosion** is defined as local corrosion at the free edges of plates, stiffeners, primary support members and around openings. An example of edge corrosion is shown in Fig.1.2.22.

1.2.23 **Grooving corrosion** is typically local material loss adjacent to weld joints along abutting stiffeners and at stiffener or plate butts or seams. An example of groove corrosion is shown in Fig.1.2.23.

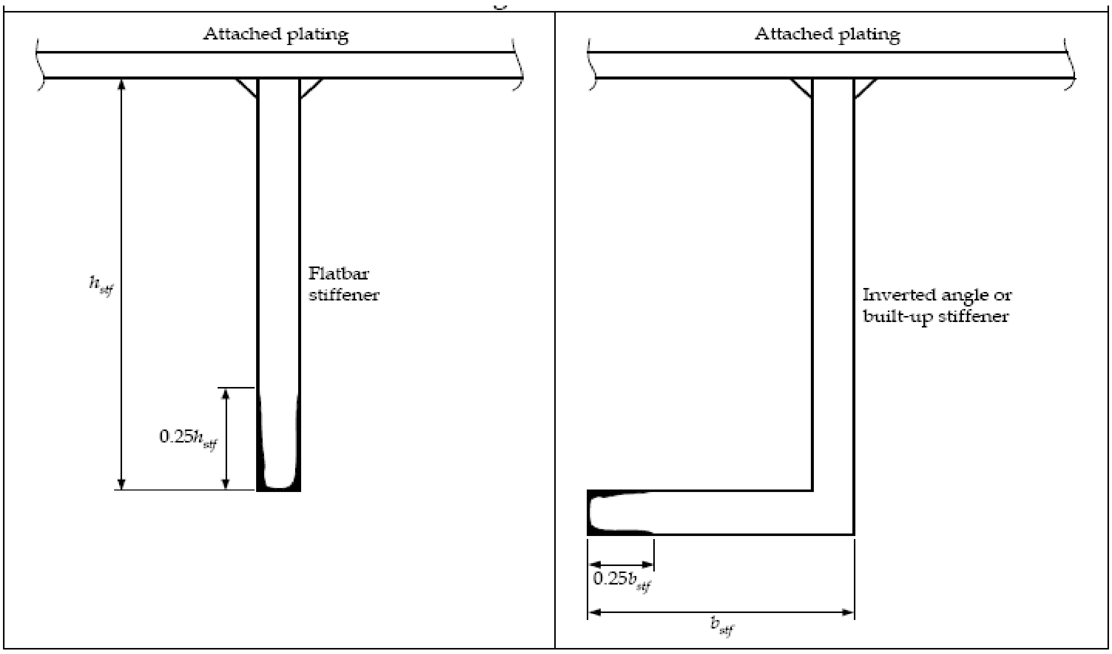

Fig. 1.2.22 : Edge corrosion

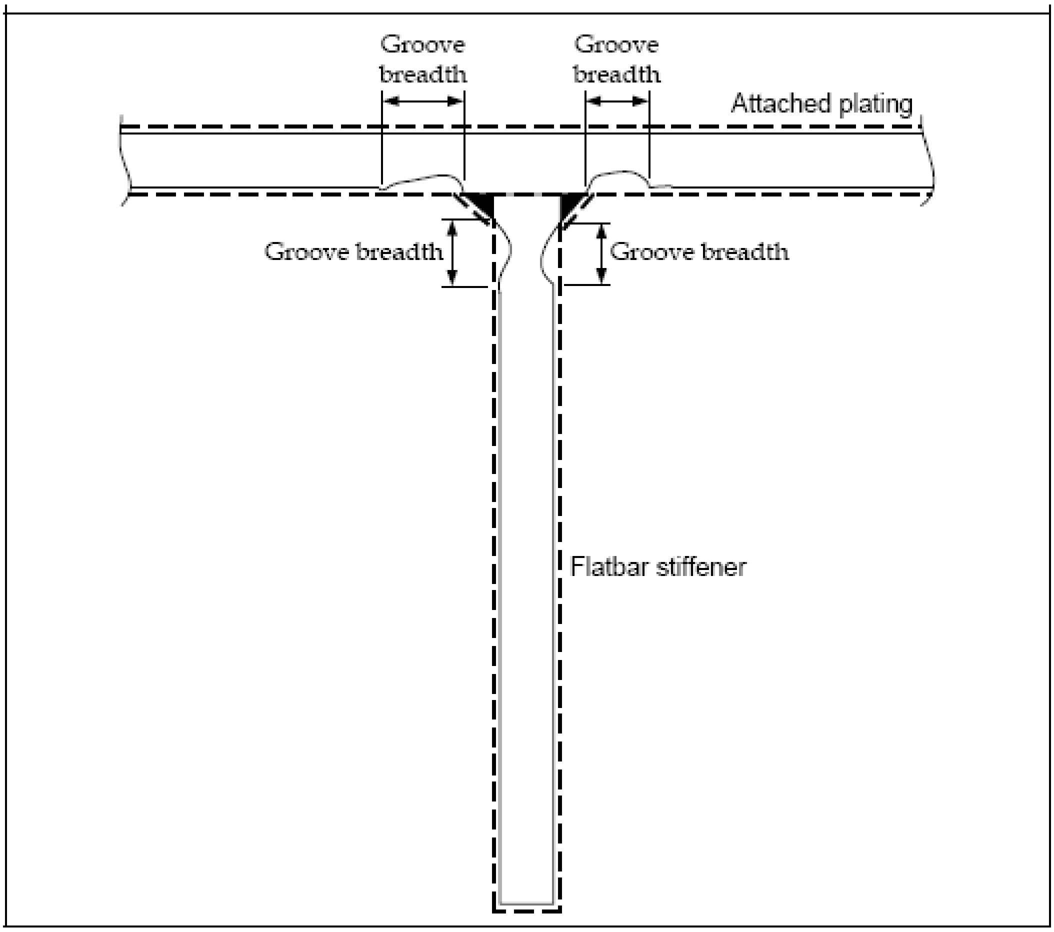

Fig. 1.2.23 : Grooving corrosion

1.3 Laid up vessels

1.3.1 Survey during lay-up

1.3.1.1 When a vessel is laid up and IRS is so informed, the periodical surveys required by 1.1.1, except Annual Surveys, may be postponed at the discretion of IRS depending upon the vessel's lay-up location, the maintenance and preservative measures taken during the lay-up. During lay-up, the vessel is to comply with the following:-

a) The vessel is to be adequately manned in accordance with the statutory requirements prevailing at the location of lay-up.

b) Adequate power is to be available on board to meet the following requirements:-

- fire fighting;
- bilge pumping;
- lighting;
- communication with shore;
- needs of crew on board, and
- operating anchor and mooring winches within a reasonable time.

1.3.1.2 During lay-up, vessels are to be subjected to a general examination every year.

1.3.2 Survey at re-activation

1.3.2.1 Vessels are to be surveyed and tested before re-entering service. The extent of the surveys and tests will be considered in each case by IRS depending upon the time out of commission, the maintenance and preservative measures taken during lay-up and the extent of surveys carried out during this time but will at least include a sea trial for function testing of the machinery installation.

1.3.2.2 Attention is drawn to the requirements of the Flag Administration regarding International Safety Management Code (ISM Code) compliance at the time of re-activation.

1.4 Surveys by Chief Engineers

1.4.1 Continuous machinery Surveys of some machinery items may be carried out, subject to certain conditions, under the supervision of the Chief Engineer of the ship at ports where IRS is not represented and where practicable, at sea.

1.4.2 A limited confirmatory Survey should be carried out at the next port of call by an exclusive Surveyor of IRS. Where IRS Surveyor is not available, such Survey may be carried out by the exclusive Surveyor of a Society with whom IRS has collaboration agreement in force with prior information given to IRS.

1.4.3 Detailed procedure of this scheme may be obtained from IRS.

1.5 Surveys for damage or alteration

1.5.1 At any time when a ship is undergoing alterations or damage repairs, any exposed parts of the structure normally difficult for access are to be specially examined by the Surveyor.

1.6 Unscheduled surveys

1.6.1 In the event that IRS has reason to believe that its Rules and Regulations are not being complied with, IRS reserves the right to perform unscheduled surveys of the hull or machinery.

1.7 Provision for surveys

1.7.1 The Surveyors are to be provided with necessary facilities for a safe execution of survey.

In order to enable the attending surveyors to carry out the survey, provisions for proper and safe access, are to be agreed between the owner and IRS in accordance with confined space safe entry procedure of IRS and IMO Resolution A1050(27) 'Revised recommend-dations for entering enclosed spaces abroad ships', as amended.

Details of the means of access are to be provided in the survey planning questionnaire.

In cases where the provisions of safety and required access are judged by the attending surveyor(s) as not adequate, the survey of the spaces concerned would not be carried out.

1.7.2 The surveys at sea or at anchorages may be carried out provided necessary precautions are taken while carrying out the survey and adequate assistance is provided.

1.7.3 Cargo holds, tanks and spaces are to be safe for access. Cargo holds, tanks and spaces are to be gas free and properly ventilated. Prior to entering a tank, void or enclosed space, it is to be verified that the atmosphere in the tank is free from hazardous gas and contains sufficient oxygen. All spaces are to be cleaned and loose accumulated corrosion scale is to be removed from all surfaces. They are to be sufficiently clean and free from water, scale, dirt, oil residues, etc. to reveal any significant corrosion, deformation, fractures, damages and other structural deterioration as well as the condition of the coating. However, those areas of structure whose renewal has already been decided by the owner need only be cleaned and descaled to the extent necessary to determine the limits of the renewal areas.

1.7.4 Sufficient illumination is to be provided to reveal corrosion, deformation, fractures, damages or other structural deterioration as well as the condition of the coating.

1.7.5 Where soft coatings have been applied, safe access is to be provided for the Surveyor to verify the effectiveness of the coating and to carry out an assessment of the conditions of the internal structures which may include spot removal of the coating. When safe access cannot be provided, the soft coating is to be removed.

1.7.6 For overall examination, means are to be provided to enable the Surveyor to examine the structure in a safe and practical way.

1.7.7 For Close-up Examination of the hull structure, other than cargo hold shell frames of bulk carriers, one or more of the following means of access to Surveyors satisfaction is to be provided, in general:

- Permanent staging and passages through structures
- Temporary staging and passages through structures
- Hydraulic arm vehicles such as conventional cherry pickers, lifts and movable platforms
- Portable ladders
- Boats or rafts
- Other equivalent means.

1.7.8

a) For close-up surveys of the cargo hold shell frames of bulk carriers less than cape size (i.e. less than 100,000 dwt) one or more of the following means for access, acceptable to the Surveyor, is to be provided:

    - Permanent staging and passage through structures;
    - Temporary staging and passages through structures;
    - Portable ladder restricted to not more than 5 [m] in length may be accepted for surveys of lower section of a shell frame including bracket;
    - Hydraulic arm vehicles such as conventional cherry pickers, lifts and movable platforms;
    - Boats or rafts, provided the structural capacity of the hold is sufficient to withstand static loads at all levels of water;
    - Other equivalent means.

b) For close-up surveys of the cargo hold shell frames of cape size bulk carriers (100,000 dwt and above), the use of portable ladders is not accepted and one or more of the following means for access, acceptable to the surveyor, is to be provided:

    i) Annual surveys, intermediate survey under 10 years of age and Special Survey No.1

        - permanent staging and passage through structures;
        - temporary staging and passages through structures;
        - hydraulic arm vehicles such as conventional cherry pickers, lifts and movable platforms;
        - boats or rafts provided the structural capacity of the hold is sufficient to withstand static loads at all levels of water;
        - other equivalent means.

    ii) Subsequent intermediate surveys and special surveys:

        - either permanent or temporary staging and passage through structures for close-up surveys of at least the upper part of hold frames;
        - hydraulic arm vehicles such as conventional cherry pickers for surveys of lower and middle part of shell frames as alternative to staging:
        - lifts and moveable platforms;
        - boats or rafts provided the structural capacity of the hold is sufficient to withstand static loads at all levels of water;
        - other equivalent means.

Notwithstanding the above requirements, the use of a portable ladder fitted with a mechanical device to secure the upper end of the ladder is acceptable for the “close-up examination of sufficient extent, minimum 25% of frames, to establish the condition of the lower region of the shell frames including approx. lower one third length of side frame at side shell and side frame end attachment and the adjacent shell plating of the forward cargo hold" at annual survey, required in 2.2.2.9b) and the "one other selected cargo hold" required in 2.2.2.10.b).

1.7.9 For bulk carriers and oil tankers constructed on or after 1 Jan 2005, the access requirements for surveys in the cargo area and forward spaces are given in Pt.5, Ch.1, Sec.1.6 & 1.7 and Pt.5, Ch.2, Sec.2.3 & 2.4 respectively. The means of access are to be surveyed prior to, or in conjunction with its use for carrying out surveys.

1.7.10 During surveys of oil tankers, ore or oil carriers, oil or bulk carriers, chemical tankers and liquefied gas carriers, explosimeter, oxygen-meter, breathing apparatus, life line and whistles are to be at hand during the survey.

1.7.11 In order to ascertain the structural strength of ship's hull and machinery, thickness measurements as specified in subsequent sections, as applicable, are to be carried out normally by means of ultrasonic equipment. The accuracy of the equipment is to be proven to the Surveyor as required.

1.7.12 One or more of the following fracture detection procedures may be required if deemed necessary by the Surveyor:

- radiographic equipment
- ultrasonic equipment
- magnetic particle equipment
- dye penetrant.

1.7.13 Explosimeter, oxygen-meter, breathing apparatus, lifelines, riding belts with rope and hook and whistles together with instructions and guidance on their use are to be made available during the survey. A safety check-list should be provided.

1.7.14 Adequate and safe lighting is to be provided for the safe and efficient conduct of the survey.

1.7.15 Adequate protective clothing is to be made available and used (e.g. safety helmet, gloves, safety shoes, etc.) during the survey.

1.7.16 If breathing apparatus and/or other equipment is used as "Rescue and emergency response equipment" then the equipment is to be suitable for the configuration of the space being surveyed.

1.8 Surveys at sea or at anchorage

1.8.1 Survey at sea or at anchorage may be accepted provided the Surveyor is given the necessary assistance from the personnel onboard. Necessary precautions and procedures for carrying out the survey are to be in accordance with 1.7.

1.8.2 A communication system is to be arranged between the survey party in the tank and the responsible officer on deck. This system must also include the personnel in charge of ballast pump handling if boats or rafts are used.

1.8.3 Surveys of tanks or applicable holds by means of boats or rafts may only be undertaken with the agreement of the Surveyor, who is to take into account the safety arrangements provided, including weather forecasting and ship response under foreseeable conditions and provided the expected rise of water within the tank due to ship motion does not exceed 0.25 [m].

1.8.4 When rafts or boats will be used for close-up survey the following conditions are to be observed:

a) Only rough duty, inflatable rafts or boats, having satisfactory residual buoyancy and stability even if one chamber is ruptured, are to be used;

b) The boat or raft is to be tethered to the access ladder and an additional person is to be stationed down the access ladder with a clear view of the boat or raft;

c) Appropriate lifejackets are to be available for all participants;

d) The surface of water in the tank or hold is to be calm (under all foreseeable conditions the expected rise of water within the tank should not exceed 0.25 m) and the water level stationary. On no account is the level of the water to be rising while the boat or raft is in use;

e) The tank, hold or space must contain clean ballast water only. Even a thin sheen of oil on the water is not acceptable; and

f) At no time is the water level to be allowed to be within 1 m of the deepest under deck web face flat so that the survey team is not isolated from a direct escape route to the tank hatch. Filling to levels above the deck transverses is only to be contemplated if a deck access manhole is fitted and open in the bay being examined, so that an escape route for the survey party is available at all times. Other effective means of escape to the deck may be considered.

g) If the tanks (or spaces) are connected by a common venting system, or inert gas system, the tank in which the boat or raft is used should be isolated to prevent a transfer of gas from other tanks (or spaces).

   The tank being examined is to be isolated also to prevent transfer of liquids/gas through cargo or ballast piping.

1.8.5 For the under deck areas in tanks, survey by means of boats or rafts will be allowed if the depth of the webs is 1.5 [m] or less.

If the depth of the webs is more than 1.5 [m], boats or rafts may be allowed only when:

i) the coating of the under deck structure is in GOOD condition and there is no evidence of wastage; or

ii) a permanent means of access is provided in each bay to allow safe entry and exit, which means the following:

   a) access direct from the deck via a vertical ladder and a small platform fitted approximately 2 [m] below the deck in each bay; or

   b) access to deck from a longitudinal permanent platform having ladders to deck in each end of the tank. The platform shall, for the full length of the tank, be arranged in level with, or above, the maximum water level needed for rafting of under deck structure. For this purpose, the ullage corresponding to the maximum water level is to be assumed not more than 3 [m] from the deck plate measured at the midspan of deck tranverses and in the middle length of the tank.

If neither of the above conditions are met, then staging or an “other equivalent means” is to be provided for the survey of the under deck areas.

See also IRS Classification Notes “Guidelines for approval / acceptance of alternative means of access to spaces in oil tankers, bulk carriers, ore carriers and combination carriers”.

1.8.6 The requirements regarding the usage of boats or rafts in 1.8.5 does not preclude their use for moving about within a tank during a survey.

1.9 Repairs

1.9.1 Any damage in association with wastage over the allowable limits (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the Surveyor, will affect the vessel's structural, watertight or weathertight integrity, is to be repaired promptly and thoroughly as defined in 1.2.13. Areas to be considered as relevant, include:

- side structure and side plating;
- deck structure and deck plating;
- bottom structure and bottom plating;
- inner bottom structure and inner bottom plating;
- inner side structure and inner side plating;
- longitudinal bulkhead(s) plating and structure;
- transverse watertight or oiltight bulkheads, plating and structure; and
- hatch covers and hatch coamings.
- weld connection between air pipes and deck plating;
- air pipe heads;
- ventilators including closing devices;
- bunker and vent piping systems in bulk carriers, ore carriers and combination carriers.

Where adequate repair facilities are not available, consideration may be given to allow the vessel to proceed directly to a repair facility. This may require discharging the cargo and/or temporary repairs for the intended voyage.

1.9.2 Additionally, when a survey results in the identification of corrosion or structural defects, either of which, in the opinion of the Surveyor, will impair the vessel's fitness for continued service, remedial measures are to be implemented before the ship continues in service.

1.9.3 Where the damage found on structure mentioned in 1.9.1 is isolated and of a localized nature which does not affect the ship’s structural integrity, consideration may be given by the surveyor to allow an appropriate temporary repair to restore watertight or weather tight integrity and impose a Recommendation / Condition of Class with a specific time limit.

1.9.4 Extended thickness measurements when required by the rules are to be carried out and necessary repairs completed before the survey is credited as complete.

1.10 Thickness measurements and close-up surveys

1.10.1 In any kind of survey, i.e. special, intermediate, annual or any other surveys having the scope of the foregoing ones thickness measurements (when required, in accordance with relevant tables of subsequent sections) of structures in areas where close-up surveys are required are to be carried out simultaneously with close-up surveys.

1.11 Extension of special surveys

1.11.1 Under “exceptional circumstances”, IRS may grant an extension not exceeding three (3) months to allow for completion of the special survey provided that the vessel is attended and the attending surveyor(s) so recommend(s) after the following has been carried out:

a) Annual Survey;
b) Re-examination of Recommendations / Conditions of Class;
c) In the case where dry docking is due prior to the end of the class extension, an underwater examination is to be carried out by an approved diving company. An underwater examination by an approved company may be dispensed with in the case of extension of dry-docking survey not exceeding 36 months interval provided the ship is without outstanding Recommendation / Condition of Class regarding underwater parts.

“Exceptional circumstances” means unavailability of dry-docking facilities; unavailability of repair facilities; unavailability of essential materials, equipment or spare parts; or delays incurred by action taken to avoid severe weather conditions.

1.11.2 In the case that the Class Certificate will expire when the vessel is expected to be at sea, an extension to allow for completion of the Special Survey may be granted provided there is documented agreement to such an extension prior to the expiry date of the certificate and provided that positive arrangements have been made for attendance of the Surveyor at the first port of call and provided that IRS is satisfied that there is technical justification for such an extension. Such an extension is to be granted only until arrival at the first port of call after the expiry date of the certificate. However, if owing to “exceptional circumstances” the special survey cannot be completed at the first port of call, 1.11.1 may be followed, but the total period of extension shall in no case be longer than three months after the original due date of the special survey.

1.11.3 In case of force majeure as defined below, the completion of survey may be specially considered.

“Force Majeure” means damage to the ship; unforeseen inability of IRS to attend the vessel due to the governmental restrictions on right of access or movement of personnel; unforeseeable delays in port or inability to discharge cargo due to unusually lengthy periods of severe weather, strikes or civil strife; acts of war; or other similar circumstances.

Section 2

Surveys - Bulk Carriers and Ore Carriers

2.1 Scope

2.1.1 This section gives the requirements for periodical surveys of vessels which have been assigned the class notations :

Bulk Carrier ESP
BC-A, B or C ESP (from July 2003)
Ore Carrier ESP

2.1.2 The requirements that are applicable only to double skin bulk carriers and those applicable only to other bulk carriers have been indicated in the relevant clauses. For bulk carrier with hybrid cargo hold arrangements, e.g. with some cargo holds of single side skin and others of double side skin, the appropriate requirements are to applied to the individual cargo holds depending on their type of side skin construction.

2.2 Annual surveys

2.2.1 General

2.2.1.1 Annual Surveys are to be carried out within 3 months before or after the anniversary date each year. These should be held concurrently with statutory annual or other relevant statutory Surveys, where practicable.

2.2.1.2 At Annual Surveys, the Surveyor is to examine the hull and machinery, so far as necessary and practicable, in order to be satisfied as to their general condition.

2.2.1.3 It is to be confirmed that no new installation of material containing asbestos was carried out since last survey.

2.2.2 Hull

2.2.2.1 The survey is to consist of an examination for the purpose of ensuring, as far as practicable, that the hull, weather decks; hatch coamings, hatch covers including their securing arrangement, other closing appliances, equipment and related piping are maintained in satisfactory and efficient condition. Special attention is to be paid to the following :

a) Weather deck, shipside plating above waterline.

b) Hatchways on freeboard and superstructure decks; exposed casings; skylights and fiddley openings; deck houses; companionways and superstructure bulkheads; side scuttles and dead lights; flush deck scuttles; ash shoots and other openings.

c) Weld connection between air pipes and deck plating; air pipe heads on exposed decks (external examination); flame screens on vents to all bunker tanks; ventilators and closing devices.

d) Scuppers and sanitary discharges as far as practicable together with valves and their controls.

e) Guard rails, bulwarks, freeing ports, gangways, walkways and life lines, fittings and appliances for timber deck cargo.

f) Watertight bulkheads and their penetrations as far as practicable.

2.2.2.2 Cargo hatch covers and coamings are to be examined to ensure that no alterations have been made to the approved arrangements :

A thorough survey of cargo hatch covers and coamings is to be carried out by examination in the open as well as closed positions and should include verification of proper opening and closing operation. The hatch cover sets within the forward 25% of the ship’s length and at least one additional set, such that all sets on the ship are assessed at least once in every 5-year period, are to be surveyed open, closed and in operation to the full extent on each direction at each annual survey, including:

i) stowage and securing in open condition;

ii) proper fit and efficiency of sealing in closed condition; and

iii) operational testing or hydraulic and power components, wires, chains and link drives.

The closing of the covers is to include the fastening of all peripheral and cross joint cleats or other securing devices. Particular attention is to be paid to the condition of the hatch covers in the forward 25% of the ship’s length, where sea loads are normally greatest.

2.2.2.3 If there are indications of difficulty in operating and securing hatch covers, sets in addition to those required by 2.2.2.2, at the discretion of the surveyor, are to be tested in operation.

Where the cargo hatch securing system does not function properly, repairs are to be carried out under the supervision of the Surveyors.

2.2.2.4 For each cargo hatch cover set the following items are to be surveyed:

a) Cover panels, including side plates and stiffener attachments that may be accessible in the open position by close-up survey (for corrosion, cracks, deformation);

b) Sealing arrangements of perimeter and cross joints (gaskets for condition and permanent deformation, flexible seals on combination carriers, gasket lips, compression bars, drainage channels and non return valves);

c) Clamping devices, retaining bars, cleating (for wastage, adjustment and condition of rubber components);

d) Closed cover locating devices (for distortion and attachments);

e) Chain or rope pulleys;

f) Guides;

g) Guide rails and track wheels;

h) Stoppers;

i) Wires, chains, tensioners and gypsies;

j) Hydraulic system, electrical safety devices and interlocks; and

k) End and interpanel hinges, pins and stools where fitted.

2.2.2.5 At each hatchway the coamings, with panel stiffeners and brackets are to be subjected to a close-up survey and checked for corrosion, cracks and deformation, especially of the coaming tops.

2.2.2.6 Where considered necessary, the effectiveness of sealing arrangements may be proved by hose or chalk testing supplemented by dimensional measurements of seal compressing components.

2.2.2.7 Cargo hatch covers of the portable type (i.e. wood or steel pontoons) are to be examined to confirm the satisfactory condition of:

- wooden covers and portable beams, carriers or sockets for the portable beams and their securing devices;

- steel pontoons;

- tarpaulins;

- cleats, battens and wedges;

- hatch securing bars and their securing devices;

- loading pads/bars and the side plate edge;

- guide plates and chocks;

- compression bars, drainage channels and drain pipes, if any.

2.2.2.8 All watertight doors in watertight bulkheads, to be examined and tested (locally and remotely) as far as practicable.

2.2.2.9 Suspect areas identified at previous special or intermediate surveys are to be close-up surveyed. Thickness measurements are to be taken of the area of substantial corrosion identified at previous surveys.

For vessels built under the IACS Common Structural Rules, the annual thickness gauging may be omitted where a protective coating has been applied in accordance with the coating manufacturer's requirements and is maintained in good condition. In this case, it is recommended that the necessary documentation of coating is available on board.

Where annual gauging is required as per 2.4.12.3, thickness measurement of aft bulk-head of the forward cargo hold is to be carried out.

2.2.2.10 Examination of ballast tanks is to be carried out when required as a consequence of the results of the special and intermediate surveys. (See 2.4.5.1, 2.4.5.2 and 2.3.2.1). When considered necessary by the Surveyor or where extensive corrosion exists, thickness measurement is to be carried out. If the results of these thickness measurements indicate substantial corrosion additional thickness measurements are to be carried out to the extent given in Table 2.4.10.2(a) or Table 2.4.10.2(b).

2.2.2.11 Anchoring and mooring equipment is to be examined as far as is practicable.

2.2.2.12 Where applicable Surveyor should satisfy himself regarding the freeboard marks on the ship's side.

2.2.2.13 The Surveyor is to confirm that, where required, an approved loading instrument together with its operation manual is available on board, See Pt.3, Ch.5. It is to be verified by the Surveyor that the loading instrument is checked for accuracy at regular intervals by the ship's staff by applying test loading conditions.

2.2.2.14 On bulk carriers of over 10 years of age the following are to be carried out in addition to the requirements in 2.2.2.1 to 2.2.2.13:

a) Overall survey of two selected cargo holds in double skin bulk carriers and all cargo holds in the case of other bulk carriers.

b) For single side skin bulk carriers, close-up survey of sufficient extent, minimum 25 per cent of frames, to establish the condition of the lower region of the shell frames including approximately lower one third length of side frame at side shell and side frame end attachment and the adjacent shell plating in a forward cargo hold. Where this level of survey reveals the need for remedial measures, the survey is to be extended to include a close-up survey of all of the shell frames and adjacent shell plating of that cargo hold as well as a close-up survey of sufficient extent of all remaining holds.

c) When considered necessary by the Surveyor, thickness measurement is to be carried out. If the results of these thickness measurements indicate substantial corrosion additional thickness measurements are to be carried out to the extent given in Table 2.4.10.2(a) or Table 2.4.10.2(b).

d) Where a hard protective coating in cargo holds is found to be in GOOD condition, the extent of close-up surveys may be specially considered.

e) All piping and penetrations in cargo holds, including overboard piping are to be examined.

2.2.2.15 On bulk carriers of over 15 years of age the following are to be carried out in addition to the requirements given in 2.2.2.1 to 2.2.2.14:

a) Overall survey of all cargo holds.

b) Close-up examination of a selected cargo hold in addition to the forward cargo hold as required in 2.2.2.14b) and c).

c) Examination of all piping and penetrations in cargo holds, including overboard piping.

d) Where a hard protective coating in cargo holds is found to be in GOOD condition, the extent of close-up surveys may be specially considered.

2.2.2.16 Accommodation ladders are to be examined at annual surveys. Satisfactory condition of the following items is to be checked, in particular :

a) steps;
b) platforms;
c) all support points such as pivots, rollers, etc.;
d) all suspension points such as lugs, brackets, etc.;
e) stanchions, rigid handrails, hand ropes and turntables;
f) davit structure, wire and sheaves, etc.

2.2.2.17 Gangways are to be examined at annual surveys. Satisfactory condition of the following items is to be checked, in particular :

a) treads;
b) side stringers, cross-members, decking, deck plates, etc.;
c) all support points such as wheel, roller, etc.;
d) stanchions, rigid handrails, hand ropes.

2.2.2.18 Winches of accommodation ladders and gangways are to be examined to verify the satisfactory condition of the following items:

a) brake mechanism including condition of brake pads and band brake, if fitted;
b) remote control system, and
c) power supply system for electric motor.

2.2.2.19 Davits and fittings on the ship’s deck associated with accommodation ladders and gangways are to be examined for satisfactory condition at annual surveys. Fittings or structures for means of access to deck such as handholds in a gateway or bulwark ladder and stanchions are also to be examined.

2.2.2.20 The maintenance and inspection records of accommodation ladders and gangways are to be verified. It is to be confirmed that supporting wires are being renewed at intervals not exceeding 5 years.

2.2.2.21 When examining internal spaces as far as practicable, the permanent means of access where appropriate, are to be verified that they remain in good condition.

2.2.2.22 For vessels subject to IMO PSPC (See Pt.3, Ch.2, 3.6), it is to be confirmed that the maintenance, repair and partial recoating of dedicated ballast tanks and double side skin spaces, as appropriate, are recorded in the coating technical file.

2.2.3 Additional annual survey requirements for ships subject to SOLAS XII/9:

2.2.3.1 For ships subject to SOLAS XII/9 i.e.:

- Bulk Carriers of 150 [m] in length and upwards of single side skin construction as defined in Pt.5, Ch.1, 1.1.4; and
- Carrying solid bulk cargoes having a density of 1780 [kg/m3] and above; and
- Contracted for construction before 1 July, 1999 and
- Constructed with an insufficient number of transverse watertight bulkheads to enable them to withstand flooding of the foremost cargo hold in all loading conditions and remain afloat in a satisfactory condition of equilibrium as specified in SOLAS XII/4.3.

2.2.3.2 In accordance with SOLAS XII/9.1 for the foremost cargo hold of such ships, the additional survey requirements listed in 2.2.3.3 to 2.2.3.6 shall apply.

2.2.3.3 For bulk carriers of 5 - 15 years of age:

a) An overall survey of the foremost cargo hold, including close-up survey of sufficient extent, minimum 25% of frames, is to be carried out to establish the condition of:

    - Shell frames including their upper and lower end attachments, adjacent shell plating, and transverse bulkheads.
    - Suspect areas found at the previous special survey.

b) Where considered necessary by the surveyor as a result of the overall and close-up survey as described in a) above, the survey is to be extended to include a close-up survey of all of the shell frames and adjacent shell plating of the cargo hold.

2.2.3.4 For bulk carriers exceeding 15 years of age:

a) An overall survey of the foremost cargo hold, including close-up survey is to be carried out to establish the condition of:

    - All shell frames including their upper and lower end attachments, adjacent shell plating and transverse bulkheads.
    - Suspect areas found at the previous special survey.

2.2.3.5 Extent of thickness measurement:

a) Thickness measurement is to be carried out to an extent sufficient to determine both general and local corrosion levels at areas subject to close-up survey, as described in 2.2.3.3a) and 2.2.3.4a) above. The minimum requirement for thickness measurements are areas found to be suspect areas at the previous special survey.

    Where substantial corrosion is found, the extent of thickness measurements is to be increased with the requirements of Table 2.4.10.2(a) or Table 2.4.10.2(b).

b) The thickness measurement may be dispensed with provided the surveyor is satisfied by the close-up survey, that there is no structural diminution and the protective coating where provided remains effective.

2.2.3.6 Where the protective coating in the foremost cargo hold is found to be in GOOD condition, the extent of close-up surveys and thickness measurements may be specially considered.

For existing bulk carriers, where owners may elect to coat or recoat cargo holds as noted above, consideration may be given to the extent of the close-up and thickness measurement surveys. Prior to the coating of cargo holds of existing ships, scantlings should be ascertained in the presence of a surveyor.

2.2.3.7 Bilge well alarms to all cargo holds and conveyor tunnels are to be verified to confirm their functionality.

2.2.4 Machinery and systems

2.2.4.1 A general examination of the machinery, boilers, all pressurised systems (steam, pneumatic, hydraulic) and their associated fittings, propulsion system and auxiliary machinery to see whether they are being properly maintained and with particular attention to the fire and explosion hazards.

2.2.4.2 Confirmation that machinery, boilers and other pressure vessels, associated piping systems and fittings are so installed and protected as to reduce to a minimum any danger to persons on board, due regard being given to moving parts, hot surfaces and other hazards.

2.2.4.3 Confirm that Periodical Surveys of boilers and other pressure vessels have been carried out as required by the Rules and the safety devices have been tested.

2.2.4.4 Confirmation that the normal operation of the propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative.

2.2.4.5 Confirmation that means are provided so that machinery can be brought into operation from the dead ship condition without external aid.

2.2.4.6 All main and auxiliary steering arrangements and their associated equipment and control systems are to be examined and tested. Where applicable, Surveyors are to verify that log entries have been made in accordance with statutory requirements.

2.2.4.7 Steering chains are to be cleaned for ascertaining wear and tear and lengths of chain worn in mean diameter by more than 12 per cent of the original rule diameter are to be renewed.

2.2.4.8 All the means of communication between the navigating bridge and the machinery control positions, as well as the bridge and the main alternative steering position, if fitted, are to be tested. It is to be confirmed that means of indicating the angular position of the rudder are operating satisfactorily.

2.2.4.9 Confirmation that with ships having emergency steering positions there are means of relaying heading information and, when appropriate, supplying visual compass readings to the emergency steering positions.

2.2.4.10 Confirmation that various alarms required for hydraulic power operated, electric and electro-hydraulic steering gears are, operating satisfactorily and that the recharging arrangements for hydraulic power operated steering gears are being maintained.

2.2.4.11 Examining the means for the operation of the main and auxiliary machinery essential for propulsion and the safety of the ship, including when applicable, the means of remotely controlling the propulsion machinery from the navigating bridge and the arrangements to operate the main and other machinery from a machinery control room.

2.2.4.12 Confirmation that the engine room telegraph, the second means of communication between the navigation bridge and the machinery space and the means of communication with any other positions from which the engines are controlled are operating satisfactorily.

2.2.4.13 Confirmation that the engineer's alarm is clearly audible in the engineer's accommodation.

2.2.4.14 The bilge pumping systems and bilge wells including operation of each bilge pump, extended spindles and level alarms, where fitted, are to be examined as far as is practicable. It is also to be confirmed that bilge pumping system for each watertight compartment is satisfactory.

It is also to be confirmed that drainage from enclosed cargo spaces situated on freeboard deck is satisfactory.

2.2.4.15 Examining visually the condition of any expansion joints in sea water system.

2.2.4.16 General examination visually and in operation, as feasible, of the main electrical machinery, the emergency sources of electrical power, the switch gear, other electrical equipment including the lighting system is to be carried out.

2.2.4.17 Confirmation as far as practicable, the operation of the emergency source(s) of electrical power, including their starting arrangement, the systems supplied, and when appropriate, their automatic operation.

2.2.4.18 Examining in general, that the precautions provided against shock, fire and other hazards of electrical origin are being maintained.

2.2.4.19 A General Examination of automation equipment is to be carried out. Satisfactory operation of safety devices, bilge level detection and alarm systems and control systems is to be verified.

2.2.4.20 Examination of bunker and vent piping systems.

2.2.4.21 For ships complying with the requirements of SOLAS XII/12 for hold, ballast and dry space water level detectors (See 2.4.14), the annual survey is to include an examination and a test, at random, of the water ingress detection systems and of their alarms.

2.2.4.22 For ships complying with the requirements of SOLAS XII/13 for the availability of pumping systems (See 2.4.15), the annual survey is to include an examination and a test, of the means for draining and pumping ballast tanks forward of the collision bulkhead and bilges of dry spaces any part of which extends forward of the foremost cargo hold and of their controls.

2.2.4.23 Confirmation that machinery space ventilation systems are in good working condition.

2.2.5 Fire protection, detection and extinction

2.2.5.1 The arrangements for fire protection, detection and extinction are to be examined and are to include confirmation that no changes have been made in the structural fire protection. Following are to be examined / verified:

a) verification that fire control plans are properly posted;

b) examination as far as possible and testing as feasible of the fire and/or smoke detection system(s);

c) examination of the fire main system and verification that each fire pump including the emergency fire pump can be operated separately so that the two required powerful jets of water can be produced simultaneously from different hydrants;

d) verification that fire hoses, nozzles, applicators and spanners are in good working condition and situated at their respective locations;

e) examination of fixed fire fighting system controls, piping, instructions and marking, checking for evidence of proper maintenance and servicing including date of last systems tests;

f) verification that all semi-portable and portable fire extinguishers are in their stowed positions, checking for evidence of proper maintenance and servicing, conducting random check for evidence of discharged containers;

g) verification, as far as practicable, that the remote controls for stopping fans and machinery and shutting off fuel supplies in machinery spaces are in working order;

h) examination of the closing arrangements of ventilators, funnel annular spaces, skylights, doorways and tunnel, where applicable;

i) confirmation that the fire fighters' outfits and emergency escape breathing devices (EEBDs) are complete and in good condition and that the cylinders, including the spare cylinders, of any required self-contained breathing apparatus are suitably charged.

j) examination of any manual and automatic fire doors and proving their operations.

k) examination of the fire-extinguishing systems for spaces containing paint and/or flammable liquids and deep fat cooking equipment in accommodation and service spaces;

l) examination of the fire safety requirements of any helicopter facilities;

m) examination of the fire protection arrangements in cargo spaces, as far as practicable;

n) examination, when appropriate of the special arrangements for carrying dangerous goods, including checking the electrical equipment and wiring, ventilation, provision of protective clothing and portable appliances and testing of the water supply, bilge pumping and any water spray system.

Surveys carried out by the National Authority of the country in which the ship is registered would normally be accepted as meeting these requirements, at the discretion of the Surveyor.

2.2.5.2 Confirmation that the means of escape from accommodation, machinery spaces and other spaces are satisfactory.

2.2.5.3 Examination of the arrangements for gaseous fuel for domestic purposes.

2.3 Intermediate Surveys

2.3.1 General

2.3.1.1 Intermediate surveys are to be carried out at or between the second or third Annual Survey.

However, only those items which are additional to the requirements of annual survey may be examined between the second or third Annual Survey.

Concurrent crediting to both Intermediate survey and Special survey for surveys and thickness measurements of spaces is not acceptable.

2.3.1.2 The following requirements are applicable for vessels over five years of age. For vessels below 5 years of age additional examination over and above the requirements of Annual survey may be required at the discretion of the Surveyors.

2.3.1.3 For vessels over 10 years of age a specific survey program is to be worked out by the owner in cooperation with the Surveyors considering the requirements of the previous special survey, executive hull summary of that survey, later relevant survey records and taking account of any amendments to the survey requirements after the last special survey. The survey program is to be submitted in written format for approval and kept on board until the intermediate survey has been completed. (See 2.4.2 for guidance on preparation of the survey program).

2.3.1.4 Prior to the commencement of any part of the intermediate survey, a survey planning meeting is to be held between the attending Surveyor(s), the owner's representative in attendance and where involved, the thickness measurement company representative and the master of ship or an appropriately qualified representative appointed by the master or Company for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

2.3.2 Vessels of between 5 and 10 years of age

2.3.2.1 Ballast tanks

a) An overall survey of representative ballast tanks is to be carried out. The selection of representative tanks is to include the fore and aft peak tanks and a number of other tanks, taking into account the total number and type of ballast tanks. When extensive corrosion is found, thickness measurements are to be carried out. If the overall survey reveals no visible structural defects, the examination may be limited to a verification that the corrosion prevention system remains efficient.

b) Where POOR coating condition, corrosion or other defects are found in ballast tanks or where a hard protective coating was not applied from the time of construction, the examination is to be extended to other ballast tanks of the same type.

c) For ballast tanks other than double bottom tanks, where a hard protective coating is found to be in POOR condition and is not renewed or where a soft or semi-hard coating has been applied or where a hard protective coating was not applied from the time of construction, the tank(s) in question are to be examined and thickness measurements carried out as necessary at subsequent annual surveys.

   When such breakdown of hard coating is found in double bottom ballast tanks, or where a soft or semi-hard coating has been applied or where a hard protective coating has not been applied, the tanks in question may be examined at annual intervals. When considered necessary by the Surveyor, or where extensive corrosion exists, thickness measurements are to be carried out.

d) Suspect areas identified at previous surveys are to be overall and close-up surveyed.

2.3.2.2 Cargo holds

a) Overall survey of all cargo holds. For single side skin bulk carriers, close-up survey of sufficient extent, minimum 25 per cent of frames, is to be carried out to establish the condition of :

- Shell frames including their end attachments, adjacent shell plating and transverse bulkheads in the forward cargo hold and one other selected cargo hold.

- Areas found suspect at the previous Special Survey.

b) For single side skin bulk carriers, where considered necessary by the Surveyor as a result of the overall and close-up survey, the survey is to be extended to include a close-up survey of all of the shell frames and adjacent shell plating of that cargo hold as well as a close-up survey of sufficient extent of all remaining cargo holds.

For double skin bulk carriers, as a result of overall survey, the survey may be extended to include a close-up survey of those areas of structure in the cargo holds selected by the Surveyor.

2.3.2.3 Extent of thickness measurements

a) Thickness measurements are to be carried out to an extent sufficient to determine both general and local corrosion levels at areas subject to close-up survey as per 2.3.2.2a). The minimum requirements for thickness measurement are the areas found to be suspect areas at the previous survey. The extent of thickness measurement may be specially considered provided the Surveyor is satisfied by the close-up survey, that there is no structural diminution and the hard protective coatings are found to be in GOOD condition.

b) Where substantial corrosion is found, the extent of thickness measurements is to be increased in accordance with the requirements of Table 2.4.10.2. Suspect areas identified at previous surveys are to be examined. Areas of substantial corrosion identified at previous surveys are to have thickness measurements taken.

For vessels built under IACS Common Structural Rules, the identified substantial corrosion areas may be:

i) protected by coating applied in accordance with the coating manufacturer's requirements and examined at annual intervals to confirm the coating in way is still in good condition, or alternatively

ii) required to be gauged at annual intervals.

In this case of i) above, it is recommended that the necessary documentation of coating is available on board.

c) Where the hard protective coating in cargo holds is found to be in GOOD condition, the extent of close-up surveys may be specially considered.

For existing bulk carriers, where owners may elect to coat or recoat cargo holds as noted above, consideration may be given to the extent of the close-up and thickness measurement surveys. Prior to the coating of cargo holds of existing ships, scantlings should be ascertained in the presence of a surveyor.

2.3.3 Vessels of between 10 and 15 years of age

2.3.3.1 The requirements of the intermediate survey are to be to the same extent as the previous special survey as required in 2.4 for hull structure and piping systems in way of the cargo holds cofferdams, pipe tunnels, void spaces and fuel oil tanks in the cargo area and all ballast tanks. However, tank testing specified in 2.4.8, survey of automatic air pipe heads specified in 2.4.6.9 and internal examination of fuel oil, lub.oil and fresh water tanks specified in Table 2.4.6.1 need not be carried out unless deemed necessary by the attending Surveyor. Thickness measurement is to be carried out for items 1) to 6) of Table 2.4.10.1.

A survey programme as per 2.4.2 is to be worked out prior to commencement of survey.

2.3.3.2 The intermediate survey may be commenced at the second annual survey and be progressed during the succeeding year with a view to completion by the third annual survey in lieu of the application of 2.4.1.4.

2.3.3.3 An in-water survey complying with the requirements of Sec.7.2 may be accepted in lieu of docking survey required by 2.4.1.9.

2.3.4 Vessels of over 15 years of age

2.3.4.1 The requirements of the intermediate survey are to be to the same extent as the previous special survey as required in 2.4 for hull structure and piping systems in way of the cargo holds cofferdams, pipe tunnels, void spaces and fuel oil tanks in the cargo area and all ballast tanks. However, tank testing specified in 2.4.8, survey of automatic air pipe heads specified in 2.4.6.9 and internal examination of fuel oil, lub.oil and fresh water tanks specified in Table 2.4.6.1 need not be carried out unless deemed necessary by the attending Surveyor. Thickness measurement is to be carried out for items 1) to 6) of Table 2.4.10.1.

A survey programme as per 2.4.2 is to be worked out prior to commencement of survey.

2.3.4.2 The intermediate survey may be commenced at the second annual survey and be progressed during the succeeding year with a view to completion by the third annual survey in lieu of the application of 2.4.1.4.

2.3.4.3 A survey in dry dock is to be part of the intermediate survey. Any remaining work in respect of the overall and close-up surveys and thickness measurements and repairs applicable to the lower portions of cargo holds and ballast tanks (i.e. parts below light ballast water line), are to be completed in the dry-dock.

2.4 Special Surveys - Hull

2.4.1 General

2.4.1.1 All ships classed with IRS are to undergo Special Surveys at 5 yearly intervals. The first Special Survey is to be completed within 5 years from the date of the initial classification survey and thereafter 5 years from the assigned date of the previous Special Survey. However, an extension of class of 3 months maximum beyond the 5th year may be granted in exceptional circumstances in accordance with 1.11. In such cases, the next period of class will start from the expiry date of the Special Survey before extension was granted.

2.4.1.2 The interval between the Special Surveys may be reduced at the request of the parties concerned or by IRS if considered appropriate.

2.4.1.3 For surveys completed within 3 months before the expiry date of the Special Survey, the next period of class will start from the expiry date of the Special Survey. For surveys completed more than 3 months before the expiry date of the Special Survey, the period of class will start from the survey completion date. In cases where the vessel has been laid up or has been out of service for a considerable period because of a major repair or modification and the owner elects to only carry out the overdue surveys, the next period of class will start from the expiry date of the special survey. If the owner elects to carry out the next due special survey, the period of class will start from the survey completion date. Any requirement of the Flag Administration in this regard is also to be complied with.

2.4.1.4 The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date. When the special survey is commenced prior to the fourth annual survey, the entire survey is to be completed within 15 months if such work is to be credited to the special survey and in this case the next period of class will start from the survey completion date.

Concurrent crediting to both Intermediate survey and Special survey for surveys and thickness measurements of spaces is not acceptable.

2.4.1.5 As part of the preparation for Special Survey, the proposed Survey Programme (See 2.4.2) including the schedule for thickness measurements (See 2.4.10) are to be submitted at least 3 months in advance of the intended commencement of the Special Survey.

2.4.1.6 Record of Special Survey will not be assigned until the Machinery Survey has been completed or postponed in agreement with IRS.

2.4.1.7 Ships which have satisfactorily passed a Special Survey will have a record entered in the Supplement to the Register Book indicating the assigned date of Special Survey. In addition a notation "ESP" will be entered for bulk carriers, ore carriers and combination carriers.

2.4.1.8 The special survey is to include, in addition to the requirements of the Annual Survey, examination, tests and checks of sufficient extent to ensure that the hull, equipment and related piping as indicated in 2.4.6.3 are in satisfactory condition and that the ship is fit for its intended purpose for the new period of class of five years to be assigned subject to proper maintenance and operation and the periodical surveys being carried out at the due dates.

2.4.1.9 A Docking Survey in accordance with the requirements of Sec.7 is to be carried out as part of the Special Survey. Any remaining work in respect of the overall and close-up surveys and thickness measurements and repairs applicable to the lower portions of cargo holds and ballast tanks (i.e. parts below light ballast water line) are to be completed in the dry-dock.

2.4.2 Planning and preparation for survey

2.4.2.1 A specific Survey Programme is to be worked out in advance of the Survey by the Owner in cooperation with the Surveyors and submitted to IRS for approval. The Survey Programme is to be in a written format based on IMO Resolution MSC197(80). The survey is not to commence until the survey programme has been agreed. Prior to the development of the survey programme, the survey planning questionnaire based on IMO Resolution MSC197(80) is to be completed by the owner and forwarded to IRS. The Survey Programme at Intermediate Survey may consist of the Survey Programme at the previous Special Survey supplemented by the Executive Hull Summary of that Special Survey and later relevant survey reports. The survey program is to be worked out taking into account any amendments to the survey requirements after the last special survey.

2.4.2.2 In developing the Survey Programme, the following documentation is to be collected and consulted with a view to selecting tanks, areas and structural areas for examination :

- Survey status and basic ship information
- Documentation on board as per 2.4.3
- Main structural plans (scantling drawings), including information regarding use of high strength steels, clad steel and stainless steel
- Relevant previous survey and inspection reports of IRS and the Owners
- Information regarding the use of the ship's holds and tanks, typical cargoes and other relevant data
- Information regarding corrosion prevention level at the time of construction
- Information regarding the relevant maintenance level during operation.

2.4.2.3 The Survey Programme submitted for approval is to account for and comply, as a minimum, with the requirements of close-up survey, thickness measurement and tank testing respectively, and to include relevant information including at least :

- Basic ship information and particulars
- Main structural plans (scantling drawings), including information regarding use of high strength steels, clad steel and stainless steel
- Plan of holds and tanks
- List of holds and tanks with information on use, corrosion prevention and condition of coating
- Conditions for survey (e.g. information like holds and tank cleaning, gas freeing, ventilation, lighting, etc.)
- Provisions and methods of access to structures
- Equipment for survey
- Nomination of holds and tanks and areas for close-up survey (As per Table 2.4.9.1)
- Nomination of sections for thickness measurement (As per Table 2.4.10.1)
- Nomination of tanks for testing
- Damage experience related to the ship in operation.

2.4.2.4 IRS will advise the Owner of the maximum acceptable structural corrosion diminution levels applicable to the vessel.

2.4.2.5 The ship is to be prepared for overall survey in accordance with the requirements of Table 2.4.2.5. The preparation is to be of sufficient extent to facilitate an examination to ascertain any excessive corrosion, deformation, fractures, damages and other structural deterioration.

2.4.2.6 Proper preparation and the close co-operation between the attending surveyor(s) and the owner's representatives onboard prior to and during the survey are an essential part in the safe and efficient conduct of the survey. During the survey on board safety meetings are to be held regularly.

Table 2.4.2.5 : Survey preparation

Special Survey No. I Age ≤ 5	Special Survey No. II 5 < Age ≤ 10	Special Survey No. III 10 < Age ≤ 15	Special Survey No. IV and subsequently Age > 15
1) The holds, deep tanks, peaks, bilges and drain wells, engine and boiler spaces and other spaces are to be cleared out and cleaned as necessary for examination. Floor plates in engine and boiler spaces are to be lifted as may be necessary for examination of the structure underneath. Where necessary ceiling, lining, casings and loose insulation are to be removed as required by the Surveyor for examination of the structure. Compositions on the plating are to be examined and sounded, but need not be disturbed if found satisfactorily adhering to the plating.	1) Requirements of Special Survey I to be complied with 2) The chain locker is to be cleaned internally. The chain cables are to be ranged for inspection. The anchors are to be cleaned and placed in an accessible position for inspection.	1) Requirements of Special Survey II to be complied with 2) Portions of wood sheathing, or other covering, on steel decks are to be removed, as considered necessary by the Surveyor, in order to ascertain the condition of the plating.	1) Requirements of Special survey III to be complied with
2) The steelwork is to be exposed and cleaned as may be required for its proper examination by the Surveyor and close attention is to be paid to the parts of the structure which are particularly liable to excessive corrosion or to deterioration due to other causes. 3) All tanks are to be cleaned as necessary to permit examination. 4) Casings or covers of air, sounding, steam and other pipes, spar ceiling and lining in way of the side scuttles are to be removed, as required by the Surveyor.			

2.4.2.7 Prior to commencement of any part of the special survey, a survey planning meeting is to be held between the attending surveyor(s), the owner's representative in attendance, the thickness measurement company representative and the master of the ship or an appropriately qualified representative appointed by the master or Company for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

2.4.2.8 The following is an indicative list of items that are to be addressed in the meeting:

a) Schedule of the vessel (i.e. the voyage, docking and undocking manoeuvres, periods alongside, cargo and ballast operations, etc.);

b) Provisions and arrangements for thickness measurements (i.e. access, cleaning/de-scaling, illumination, ventilation, personal safety);

c) Extent of the thickness measurements;

d) Acceptance criteria (refer to the list of minimum thicknesses);

e) Extent of close-up survey and thickness measurement considering the coating condition and suspect areas/areas of substantial corrosion;

f) Execution of thickness measurements;

g) Taking representative readings in general and where uneven corrosion / pitting is found;

h) Mapping of areas of substantial corrosion; and

i) Communication between attending surveyor(s) the thickness measurement company operator(s) and owner representative(s) concerning findings.

2.4.3 Documentation on board

2.4.3.1 The Owners are to obtain, supply and maintain on board documentation as specified in 2.4.3.3, which is to be readily available for the Surveyor.

2.4.3.2 The documentation is to be kept on board for the life time of the ship.

2.4.3.3 A Survey Report File is to be a part of the documentation on board consisting of

- Reports of structural surveys
- Executive Hull Summary
- Thickness measurement reports.

2.4.3.4 The Survey Report File is to be available also in the Owners and the Classification Society's management offices.

2.4.3.5 The following additional supporting documentation is to be available on board:

Main structural plans of cargo holds and ballast tanks (for CSR ships these plans are to include for each structural element both the as-built and renewal thickness. Any thickness for voluntary addition is also to be clearly indicated on the plans. The midship section plan to be supplied on board the ship is to include the minimum allowable hull girder sectional properties for hold transverse section in all cargo holds)

- Previous repair history
- Cargo and ballast history
- Inspection by ship's personnel with reference to
  - structural deterioration in general
  - leakages in bulkheads and piping
  - condition of coating or corrosion prevention system, if any
- Any other information that will help identify critical structural areas and/or Suspect Areas requiring inspection.
- Survey Programme as required by 2.4.2 until such time as the Special Survey has been completed.

2.4.3.6 Prior to survey, the Surveyor is to examine the completeness of the documentation on board, and its contents as a basis for the survey.

2.4.4 Surveys at sea or at anchorage

2.4.4.1 See Sec.1.8.

2.4.5 Space protection

2.4.5.1 Where provided, the condition of coating or corrosion protection of cargo holds and ballast tanks is to be examined. For ballast tanks excluding double bottom tanks where a hard protective coating is found in POOR condition and it is not renewed or where soft or semi-hard coating has been applied, or where a hard protective coating was not applied from the time of construction, the tanks in question are to be examined at annual surveys. Thickness measurements are to be carried out as deemed necessary by the Surveyor.

2.4.5.2 When such breakdown of hard protective coating is found in double bottom ballast tanks and it is not renewed, where a soft or semi-hard coating has been applied, or where a hard protective coating has not been applied from the time of construction, the tanks in question may be examined at annual intervals. When considered necessary by the Surveyor or where extensive corrosion exists, thickness measurements are to be carried out.

2.4.5.3 Areas in spaces where a hard protective coating is provided and found in GOOD condition, the extent of close-up surveys and thickness measurements may be specially considered.

Areas in tanks where a hard protective coating is provided and found in GOOD condition, the extent of thickness measurements may be specially considered.

2.4.6 Survey and examination

2.4.6.1 All spaces within the hull and superstructure are to be examined.

2.4.6.2 All tanks other than water ballast tanks are to be examined internally in accordance with the requirements of Table 2.4.6.1.

Table 2.4.6.1 : Requirements for internal examination of tanks

Tank	Special Survey No. I Age ≤ 5	Special Survey No. II 5 < Age ≤ 10	Special Survey No. III 10 < Age ≤ 15	Special Survey No. IV and subsequent Age > 15
Fuel oil bunker tanks - Engine room - Cargo area	 None None	 None One	 One Two	 One Half the number of tanks, minimum 2
Lub.oil	None	None	None	One
Fresh water	None	One	All	All

Notes:

1) These requirements apply to tanks of integral (structural) type.
2) If a selection of tanks is accepted to be examined, then different tanks are to be examined at each special survey, on a rotational basis.
3) Peak tanks (all uses) are subject to internal examination at each special survey.
4) At special survey No.III and subsequent special surveys, one deep tank for fuel oil in the cargo area is to be included, if fitted.

2.4.6.3 An overall survey of all cargo holds, ballast tanks including double bottom tanks, pipe tunnels, cofferdams and void spaces bounding cargo holds, decks and outer hull is to be carried out. This examination is to be supplemented by thickness measurement and testing as required by 2.4.10 and 2.4.8 to ensure that the structural integrity remains effective. The aim of the examination is to discover Substantial Corrosion, significant deformation, fractures, damages or other structural deterioration and if deemed necessary by the Surveyor, a suitable non-destructive examination may be required.

All piping systems within the above spaces are to be examined and operationally tested to working pressure to attending Surveyors satisfaction to ensure that the tightness and condition remains satisfactory.

2.4.6.4 Where ballast tanks have been converted to void spaces, the survey extent is to be based upon ballast tank requirements.

2.4.6.5 All watertight bulkheads and watertight doors are to be examined. All decks, casings and superstructures are to be examined. Attention is to be given to the corners of openings and other discontinuities in way of the strength decks and top sides.

2.4.6.6 The masts, standing rigging and anchors are to be examined.

The Surveyor should satisfy himself that there are sufficient mooring ropes on board and also that a tow line is provided when this is a Rule requirement.

2.4.6.7 The steering gear, and its connections and control systems (main and alternative) are to be examined. The auxiliary steering gear with its various parts are to be examined in working condition.

2.4.6.8 The hand pumps and suctions, air and sounding pipes are to be examined. The Surveyors are to ensure that striking plates are fitted under the sounding pipes whilst examining the tanks internally

Automatic air pipe heads are to be internally examined at special surveys as indicated in Table 2.4.6.8. For designs where the inner parts cannot be properly inspected from outside, the head is to be removed from the air pipe. Particular attention is to be paid to the condition of the zinc coating in heads constructed from galvanised steel.

Table 2.4.6.8 : Requirements for internal examination of automatic air pipe heads

Location	**Special survey No.I** **Age ≤ 5**	**Special survey No.II** **5 < Age ≤ 10**	**Special survey No.III and subsequent** **Age > 10**
forward 0.25L	Two air pipe heads[1,2] one port and one starboard on exposed decks	All air pipe heads on exposed decks	All air pipe heads[3] on exposed decks
aft of 0.25L from the forward perpendicular	Two air pipe heads[1,2] one port and one starboard on exposed decks	At least 20% of air pipe heads[1,2] on exposed decks	

Notes:

1. Preferably air pipes serving ballast tanks.
2. The selection of air pipe heads is to be made by the attending Surveyor. According to the results of the inspection, the Surveyor may require additional air pipe heads to be examined.
3. When there is substantiated evidence of replacement within the previous five years, individual air pipe heads may not be examined.

2.4.6.9 The Surveyor should satisfy himself regarding the efficient condition of the following :

– Means of escape from machinery spaces, crew and passenger spaces and spaces in which crew are normally employed;

- Means of communication between bridge and engine room and between bridge and alternative steering position;

- Helm indicator;

- Protection to the aft steering wheel and the gear.

2.4.6.10 The chain cables are to be ranged and the anchors and the chain cables are to be examined. At special survey no. II and subsequent special surveys, the chain cables are to be gauged. Any length of chain cable which is found to have reduced in mean diameter at its most worn part by more than 12 per cent of its original rule diameter is to be renewed.

2.4.6.11 The windlass is to be examined.

2.4.6.12 The chain locker, hold fasts, hawse pipes and chain stoppers are to be examined and pumping arrangements of the chain locker tested.

2.4.6.13 Engine room structure is to be examined. Particular attention being given to tank tops, shell plating in way of tank tops, brackets connecting side shell frames and tank tops and engine room bulkheads in way of tank tops and bilge wells. Where excessive areas of wastage are found, thickness measurements are to be carried out and renewals of repairs made when wastage exceeds allowable limits.

2.4.6.14 The loading instrument is to be checked for accuracy by applying test load conditions in presence of the Surveyor.

2.4.6.15 For ships complying with the requirements of SOLAS XII/12 for hold, ballast and dry space water level detectors, the special survey is to include an examination and a test of the water ingress detection systems and of their alarms.

2.4.6.16 For ships complying with the requirements of SOLAS XII/13 for the availability of pumping systems, the special survey is to include an examination and a test of the means for draining and pumping ballast tanks forward of the collision bulkhead and bilges of dry spaces any part of which extends forward of the foremost cargo hold and of their controls.

2.4.6.17 Examination of accommodation ladders, gangways and their winches are to be carried out as required for annual surveys. In addition, the accommodation ladders and gangways are to be operationally, tested with the specified maximum operation load.

The tests are to be carried out with the load applied as uniformly as possible along the length of the accommodation ladder or gangway, at an angle of inclination corresponding to the maximum bending moment on the accommodation ladder or gangway.

Accommodation ladder winch is to be operationally tested at special surveys. The brake system of the winch is to be tested for holding the maximum operational load on the ladder.

For existing installations on board ships constructed prior to 01 Jan 2010 where the maximum operational load is not known, load nominated by the shipowner or operator may be considered as the test load.

2.4.7 Hatch covers and coamings

The hatch covers and coamings are to be surveyed as follows:

2.4.7.1 A thorough inspection of the items listed in 2.2.2.2 is to be carried out in addition to all hatch covers and coamings.

2.4.7.2 Checking of the satisfactory operation of all mechanically operated hatch covers is to be made, including:

- stowage and securing in open condition;

- proper fit and efficiency of sealing in closed condition;

- operational testing of hydraulic and power components, wires, chains and link drives.

2.4.7.3 Checking the effectiveness of sealing arrangements of all hatch covers by hose testing or equivalent.

2.4.7.4 Close up survey and thickness measurement of the hatch cover and coaming plating and stiffeners is to be carried out as given in the relevant tables.

2.4.8 Tank testing

2.4.8.1 Boundaries of double bottom, deep, ballast, peak and other tanks including holds adapted for the carriage of water ballast, are to be tested with a head of liquid to the top of air pipes or nearabout to the top of hatches for ballast/cargo holds. Boundaries of fuel oil, lub.oil and fresh water tanks are to be tested with a head of liquid to the highest point that liquid will rise under service conditions. Tank testing of fuel oil, lub.oil and fresh water tanks may be specially considered based on a satisfactory external examination of the tank boundaries and a confirmation from the Master stating that the pressure testing has been carried out according to the requirement with satisfactory results.

2.4.8.2 The testing of double bottom tanks and other spaces not designed for the carriage of liquid may be omitted, provided a satisfactory internal examination together with an examination of the tank top is carried out.

2.4.9 Close-up surveys

2.4.9.1 The minimum requirements for Close-up survey are given in Table 2.4.9.1(a) or Table 2.4.9.1(b) or Table 2.4.9.1(c).

Table 2.4.9.1a : Requirements of close-up survey - Dry bulk cargo ships other than double skin bulk carriers

Special Survey No. I Age ≤ 5	Special Survey No. II 5 < Age ≤ 10	Special Survey No. III 10 < Age ≤ 15	Special Survey No. IV and subsequently Age > 15
A) 25% of frames in the forward cargo hold at representative positions A) Selected frames in all cargo holds	A) All shell frames in the forward cargo hold and 25% of frames in remaining cargo holds including upper and lower end attachments and adjacent shell plating For bulk carriers of 100,000 dwt and above all shell frames in the forward cargo hold and 50% of shell frames in each of the remaining cargo holds, including upper and lower end attachments and adjacent shell plating	A) All shell frames in the forward cargo hold and one other selected cargo hold and 50% of frames in remaining cargo holds including upper and lower end attachments and adjacent shell plating	A) All shell frames including their upper and lower end attachments and adjacent shell plating in all cargo holds.
B) One transverse web with associated plating and longitudinals in two representative ballast tanks of each type (i.e. topside or hopper side tank)	B) One transverse web with associated plating and longitudinals in each ballast tank B) Forward and aft transverse bulkhead in one ballast tank, including stiffening system	B) All transverse webs with associated plating and longitudinals in each ballast tank B) All transverse bulkheads in ballast tanks, including stiffening system	B) All transverse webs with associated plating and longitudinals in each ballast tank B) All transverse bulkheads in ballast tanks, including stiffening system
C) Two selected cargo hold transverse bulk-heads including internal structure of upper and lower stools, where fitted	C) All cargo hold trans-verse bulkheads including internal structure of upper and lower stools, where fitted	C) All cargo hold transverse bulkheads including internal structure of upper and lower stools, where fitted	C) All cargo hold transverse bulkheads including internal structure of upper and lower stools, where fitted
D) All cargo hold hatch covers and coamings (plating and stiffeners)	D) All cargo hold hatch covers and coamings (plating and stiffeners)	D) All cargo hold hatch covers and coamings (plating and stiffeners)	D) All cargo hold hatch covers and coamings (plating and stiffeners)
	E) All deck plating and underdeck structure inside line of hatch openings between all cargo hold hatches	E) All deck plating and underdeck structure inside line of hatch openings between all cargo hold hatches	E) All deck plating and underdeck structure inside line of hatch openings between all cargo hold hatches

A) Cargo hold transverse frames

B) Transverse web frame or watertight transverse bulkhead in ballast tanks

C) Cargo hold transverse bulkheads plating, stiffeners and girders

D) Cargo hold hatch covers and coamings. Close up survey/thickness measurement is to be carried out for accessible parts of hatch cover structures. For cargo hold hatch covers of approved design which have no access to internal structures, close up survey/thickness measurements of such inaccessible structural members need not be carried out.

E) Deck plating and underdeck structure inside line of hatch openings, between cargo hold hatches

Table 2.4.9.1a : (Contd.)	
Note : Close-up survey of transverse bulkheads to be carried out at four levels -	
Level (a)	Immediately above the inner bottom and immediately above the line of gussets (if fitted) and shedders for ships without lower stool.
Level (b)	Immediately above and below the lower stool shelf plate (for those ships fitted with lower stools) and immediately above the line of the shedder plates.
Level (c)	About mid-height of the bulkhead.
Level (d)	Immediately below the upper deck plating and immediately adjacent to the upper wing tank and immediately below the upper stool shelf plate for those ships fitted with upper stools, or immediately below the topside tanks.

Table 2.4.9.1b : Minimum requirements for close-up survey at special hull survey of double skin bulk carriers other than ore carriers

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequently** **Age > 15**
One transverse web with associated plating and longitudinals in two representative ballast tanks of each type (This is to include the foremost topside and double side ballast tanks on either side) **(A)**	One transverse web with associated plating and longitudinals as applicable in each ballast tank **(A)**	All transverse webs with associated plating and longitudinals as applicable in each ballast tank **(A)**	All transverse webs with associated plating and longitudinals as applicable in each ballast tank **(A)**
	Forward and aft transverse bulkheads including stiffening system in the topside, hopper side and double side ballast tanks on one side of the ship (i.e. port or starboard) that fall in one transverse section **(A)**	All transverse bulkheads including stiffening system in each ballast tank **(A)**	All transverse bulkheads including stiffening system in each ballast tank **(A)**
	25% of ordinary transverse frames for transverse framing system or 25% of longitudinals for longitudinal framing system on side shell and inner side plating at forward, middle and aft parts,in the foremost double side tanks **(B)**	25% of ordinary transverse frames for transverse framing system or 25% of longitudinals for longitudinal framing system on side shell and inner side plating at forward, middle and aft parts,in all double side tanks **(B)**	All ordinary transverse frames for transverse framing system or all of longitudinals for longitudinal framing system on side shell and inner side plating at forward, middle and aft parts,in all double side tanks **(B)**
Two selected cargo hold transverse bulkheads, including internal structure of upper and lower stools, where fitted **(C)**	One transverse bulkhead in each cargo hold, including internal structure of upper and lower stools, where fitted **(C)**	All cargo hold transverse bulkheads, including internal structure of upper and lower stools, where fitted **(C)**	Areas **(C)** - **(E)** as for SS No.III

<table>
<tr><th colspan="4">Table 2.4.9.1b (Contd.)</th></tr>
<tr><th>Special Survey No. I
Age ≤ 5</th><th>Special Survey No. II
5 < Age ≤ 10</th><th>Special Survey No. III
10 < Age ≤ 15</th><th>Special Survey No. IV and subsequently
Age > 15</th></tr>
<tr><td>All cargo hold hatch covers and coamings (plating and stiffeners) (D)</td><td>All cargo hold hatch covers and coamings (plating and stiffeners) (D)</td><td>All cargo hold hatch covers and coamings (plating and stiffeners) (D)</td><td></td></tr>
<tr><td></td><td>All deck plating and under deck structure inside line of hatch openings between all cargo hold hatches (E)</td><td>All deck plating and under deck structure inside line of hatch openings between all cargo hold hatches (E)</td><td></td></tr>
<tr><td colspan="4">(A), (B), (C), (D) and (E) are areas to be subjected to close-up surveys and thickness measurements.</td></tr>
<tr><td colspan="4">(A) : Transverse web frame or watertight transverse bulkhead in topside, hopper side and double side ballast tanks. In fore and aft peak tanks transverse web frame means a complete transverse web frame ring including adjacent structural members.
(B) : Ordinary transverse frame in double side tanks.
(C) : Cargo hold transverse bulkheads plating, stiffeners and girders.
(D) : Cargo hold hatch covers and coamings. Close up survey/thickness measurement is to be carried out for accessible parts of hatch cover structures. For cargo hold hatch covers of approved design which have no access to internal structures, close up survey/thickness measurements of such inaccessible structural members need not be carried out.
(E) : Deck plating inside line of hatch openings between cargo hold hatches.</td></tr>
<tr><td colspan="4">Note : Close-up survey of transverse bulkheads to be carried out at four levels.</td></tr>
<tr><td colspan="4">Level (a) : Immediately above the inner bottom and immediately above the line of gussets (if fitted) and shedders for ships without lower stool.</td></tr>
<tr><td colspan="4">Level (b) : Immediately above and below the lower stool shelf plate (for those ships fitted with lower stools) and immediately above the line of the shedder plates.</td></tr>
<tr><td colspan="4">Level (c) : About mid-height of the bulkhead.</td></tr>
<tr><td colspan="4">Level (d) : Immediately below the upper deck plating and immediately adjacent to the upper wing tank and immediately below the upper stool shelf plate for those ships fitted with upper stools, or immediately below the topside tanks.</td></tr>
</table>

Table 2.4.9.1c : Minimum requirements for close-up survey at special hull survey of ore carriers

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequently** **Age > 15**
One web frame ring complete including adjacent structural members in a ballast wing tank **(A)** One transverse bulkhead lower part – including girder system and adjacent structural members – in a ballast tank **(A)**	All web frame rings complete including adjacent structural members in a ballast wing tank **(A)** One deck transverse including adjacent deck structural members in each remaining ballast tank **(A)** Forward and aft transverse bulkheads complete – including girder system and adjacent structural members – in a ballast wing tank **(A)**	All web frame rings complete including adjacent structural members in each ballast wing tank **(A)** All transverse bulkheads complete – including girder system and adjacent structural members – in each ballast tank **(A)** One web frame ring complete including adjacent structural members in each wing void space **(A)**	As for special survey for age from 10 to 15 years
	One transverse bulkhead lower part – including girder system and adjacent structural members – in each remaining ballast tank **(A)**	Additional web frame rings in void spaces as deemed necessary by the Surveyor **(A)**	
Two selected cargo hold transverse bulkheads, including internal structure of upper and lower stools, where fitted **(C)**	One transverse bulkhead in each cargo hold, including internal structure of upper and lower stools, where fitted **(C)**	All cargo hold transverse bulkheads, including internal structure of upper and lower stools, where fitted **(C)**	Areas **(C) – (E)** as for age interval 10 to 15 years
All cargo hold hatch covers and coamings (plating and stiffeners) **(D)**	All cargo hold hatch covers and coamings (plating and stiffeners) **(D)**	All cargo hold hatch covers and coamings (plating and stiffeners) **(D)**	
	All deck plating and under deck structure inside line of hatch openings between all cargo hold hatches **(E)**	All deck plating and under deck structure inside line of hatch openings between all cargo hold hatches **(E)**	

(A), (C), (D) and **(E)** are areas to be subjected to close-up surveys and thickness measurements

(A) :	Transverse web frame or watertight transverse bulkhead in ballast wing tanks and void spaces. In fore and aft peak tanks transverse web frame means a complete transverse web frame ring including adjacent structural members
(C) :	Cargo hold transverse bulkheads plating, stiffeners and girders
(D) :	Cargo hold hatch covers and coamings. Close up survey/thickness measurement is to be carried out for accessible parts of hatch cover structures. For cargo hold hatch covers of approved design which have no access to internal structures, close up survey/thickness measurements of such inaccessible structural members need not be carried out.
(E) :	Deck plating and under deck structure inside line of hatch openings between cargo hold hatches

Table 2.4.9.1c (Contd.)	
Note : Close-up survey of transverse bulkheads to be carried out at four levels:	
Level (a) :	Immediately above the inner bottom and immediately above the line of gussets (if fitted) and shedders for ships without lower stool.
Level (b) :	Immediately above and below the lower stool shelf plate (for those ships fitted with lower stools) and immediately above the line of the shedder plates.
Level (c) :	About mid-height of the bulkhead.
Level (d) :	Immediately below the upper deck plating and immediately adjacent to the upper wing tank and immediately below the upper stool shelf plate for those ships fitted with upper stools, or immediately below the topside tanks.

2.4.9.2 The Surveyor may extend the close-up survey as deemed necessary taking into account the maintenance of the spaces under survey, the condition of the corrosion prevention system and where spaces have structural arrangements or details which have suffered defects in similar spaces or on similar ships according to available information.

2.4.9.3 For areas in tanks and cargo holds where hard protective coatings are found in GOOD condition, the extent of Close-up survey may be specially considered.

2.4.10 Thickness measurement

2.4.10.1 The minimum requirement for thickness measurement at special survey are given in Table 2.4.10.1.

2.4.10.2 Provisions for extended measurements for areas with Substantial Corrosion in case of dry bulk cargo ships are given in Table 2.4.10.2(a) and Table 2.4.10.2(b) and may be additionally specified in the survey programme as required by 2.4.2. Areas of substantial corrosion identified at the previous surveys are to have thickness measurements taken.

For vessels built under IACS Common Structural Rules, the identified substantial corrosion areas may be:

a) Protected by coating applied in accordance with the coating manufacturer’s requirements and examined at annual intervals to confirm the coating in way is still in good condition, or alternatively

b) Required to be gauged at annual intervals.

In this case of a) above, it is recommended that the necessary documentation of coating is available on board.

The Surveyor may further extend the thickness measurements as deemed necessary.

2.4.10.3 Transverse sections are to be chosen where the largest reductions are suspected to occur or are revealed from deck plating measurements, one of which is to be in the amidships area.

2.4.10.4 Representative thickness measurement to determine both general and local levels of corrosion in the shell frames and their end attachments in all cargo holds and ballast tanks is to be carried out.

Thickness measurement is also to be carried out to determine the corrosion levels on the transverse bulkhead plating.

The extent of thickness measurements may be specially considered provided the Surveyor is satisfied by the close-up survey, that there is no structural diminution and the hard protective coating where applied remains efficient.

Table 2.4.10.1 : Thickness measurement at special hull survey of dry bulk cargo ships (including double skin bulk carriers)

Special Survey No. I Age ≤ 5	Special Survey No. II 5 < Age ≤ 10	Special Survey No. III 10 < Age ≤ 15	Special Survey No. IV and subsequently Age > 15
1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel
	2) Within the cargo area: a) 2 transverse sections of deck plating outside line of cargo hatch opening b) Wind and water strakes in way of the transverse sections considered in item (a) above	2) Within the cargo area: a) Each deck plate outside line of cargo hatch openings b) 2 transverse sections, one in the amidship area, outside line of cargo hatch openings c) All wind and water strakes	2) Within the cargo area: a) Each deck plate outside line of cargo hatch openings b) 3 transverse sections, one in the amidship area, outside line of cargo hatch openings c) All wind and water strakes d) Each bottom plate e) Duct keel or pipe tunnel plating and internals
	3) Measurement, for general assessment and recording of corrosion pattern, of those structural members subject to Close-up Survey according to Table 2.4.9.1(a) or Table 2.4.9.1(b), as applicable	3) Measurement, for general assessment and recording of corrosion pattern, of those structural members subject to Close-up Survey according to Table 2.4.9.1(a) or Table 2.4.9.1(b), as applicable	3) Measurement, for general assessment and recording of corrosion pattern, of those structural members subject to Close-up Survey according to Table 2.4.9.1(a) or Table 2.4.9.1(b), as applicable
	4) For vessels where UR S31 applies as mentioned in Table 2.4.13.1, additional thickness measurement of side shell frames and brackets for verifying compliance with UR S31.	4) Same as for special survey II	4) Same as for special survey II
	5) Selected wind and water strakes outside the cargo area	5) Selected wind and water strakes outside the cargo area	5) All wind and water strakes outside the cargo area
		6) For vessels subject to compliance of IMO standards as mentioned in 2.4.12 thickness measurement applicable to the vertically corrugated aft transverse bulkhead of the foremost cargo hold is to be carried out as per Table 2.4.12 and Fig.2.4.12	6) Same as for Special Survey III

Table 2.4.10.1 (Contd.)			
Special Survey No. I Age ≤ 5	**Special Survey No. II 5 < Age ≤ 10**	**Special Survey No. III 10 < Age ≤ 15**	**Special Survey No. IV and subsequently Age > 15**
		7) Internals in forepeak and after peak tanks	7) Internals in forepeak and after peak tanks
			8) All exposed main deck plating outside cargo area
			9) Representative exposed superstructure deck plating (poop, bridge, forecastle deck)
			10) All keel plates, additional bottom plates in way of machinery space, aft end of tanks and cofferdams outside cargo area
			11) a) Plating of sea chests. b) Shell plating in way of overboard discharges as considered necessary by the Surveyor.

Table 2.4.10.2a : Requirements for extent of thickness measurement on areas of substantial corrosion in dry bulk cargo ships other than double skin bulk carriers			
Structural Member		**Extent of Measurement**	**Pattern of Measurement**
Deck Structure including Cross Strips, Main Cargo Hatchways, Hatch Covers, Coamings and Topside Tanks			
1	Cross deck strip plating	Suspect cross deck strip plating	5 point pattern between underdeck stiffeners over 1 metre in length
2	Underdeck stiffeners	Transverse members	5 point pattern at each end and mid span
		Longitudinal members	5 point pattern on both web and flange
3	Hatch covers	Side and end skirts, each 3 locations	5 point pattern at each location
		3 longitudinal bands, 2 outboard strakes and centreline strake	5 point measurement each band
4	Hatch coaming	Each side and end of coaming, one band lower 1/3, one band upper 2/3 of coaming	5 point measurement of each band, i.e. end or side coaming
5	Topside ballast tanks	a) Watertight transverse bulkheads	
		i) lower 1/3 of bulkhead	i) 5 point pattern over 1 sq. metre of plating
		ii) upper 2/3 of bulkhead	ii) 5 point pattern over 1 sq. metre of plating
		iii) stiffeners	iii) 5 point pattern over 1 metre length
		b) 2 Representative swash transverse bulkheads	
		i) lower 1/3 of bulkhead	i) 5 point pattern over 1 sq. metre of plating
		ii) upper 2/3 of bulkhead	ii) 5 point pattern over 1 sq. metre of plating
		iii) stiffeners	iii) 5 point pattern over 1 metre length
		c) 3 Representative bays of slope plating	
		i) lower 1/3 of tank	i) 5 point pattern over 1 sq. metre of plating
		ii) upper 2/3 of tank	ii) 5 point pattern over 1 sq. metre of plating
		d) Longitudinals, suspect and adjacent areas	5 point pattern both web and flange over 1 metre length
6	Main deck plating	Suspect plates and adjacent areas	5 point pattern over 1 metre length of plating
7	Main deck longitudinals	Minimum of 3 longitudinals where plating measured	5 point pattern both web and flange over 1 metre length
8	Web frames/transverses	Suspect plates	5 point pattern over 1 sq. metre
Double Bottom and Hopper Structure			
1	Inner/double bottom plating	Suspect plates plus all adjacent plates	5 point pattern for each panel between longitudinals over 1 metre length
2	Inner/double bottom longitudinals	Three longitudinals where plates measured	3 measurements in line across web and 3 measurements on flange
3	Longitudinal girders or transverse floors	Suspect plates	5 point pattern over about 1 sq. metre
4	Watertight bulkheads (WT floors)	a) lower 1/3 of tank	a) 5 point pattern over 1 sq. metre of plating
		b) upper 2/3 of tank	b) 5 point pattern alternate plates over 1 sq. metre of plating
5	Web frames	Suspect plates	5 point pattern over 1 sq. metre of plating
6	Bottom/side shell longitudinals	Minimum of three longitudinals in way of suspect areas	3 measurements in line across web
			3 measurements on flange

Table 2.4.10.2a (Contd.)

Structural Member		**Extent of Measurement**	**Pattern of Measurement**
Cargo Holds			
1	Side shell frames	Suspect stiffener and each adjacent area	a) At each end and mid span: 5 point pattern of both web and flange
			b) 5 point pattern within 25 mm of welded attachment to both shell and lower slope plate
Shell Structures			
1	Bottom and side shell plating	a) Suspect plate, plus four adjacent plates	a) 5 point pattern for each panel between longitudinals
		b) See other tables for particulars on gauging in way of tanks and cargo holds	
2	Bottom/side shell longitudinals	Minimum of three longitudinals in way of suspect areas	3 measurements in line across web 3 measurements on flange
Transverse Bulkheads in Cargo Holds			
1	Lower stool	a) Transverse band within 25 mm of welded connection to inner bottom	a) 5 point between stiffeners over 1 metre length
		b) Transverse band within 25 mm of welded connection to shelf plate	b) 5 point between stiffeners over 1 metre length
2	Transverse bulkhead	a) Transverse band at approximately mid height	a) 5 point between stiffeners over 1 sq. metre of plating
		b) Transverse band at part of bulkhead adjacent to upper deck or below upper stool shelf plate (for those ships fitted with upper stools)	b) 5 point between stiffeners over 1 sq. metre of plating

Table 2.4.10.2b : Requirements for extent of thickness measurements on areas of substantial corrosion of double skin bulk carriers

Structural member	**Extent of measurement**	**Pattern of measurement**
Bottom, inner bottom and hopper structure		
Bottom, inner bottom and hopper structure plating	Minimum of three bays across double bottom tank, including aft bay	5-point pattern for each panel between longitudinals and floors
	Measurements around and under all suction bell mouths	
Bottom, inner bottom and hopper structure longitudinals	Minimum of three longitudinals in each bay where bottom plating measured	Three measurements in line across flange and three measurements on vertical web
Bottom girders, including the watertight ones	At fore and aft watertight floors and in centre of tanks	Vertical line of single measurements on girder plating with one measurement between each panel stiffener or a minimum of three measurements
Bottom floors, including the watertight ones	Three floors in bays where bottom plating measured, with measurements at both ends and middle	5-point pattern over two square meter area
Hopper structure web fame ring	Three floors in bays where bottom plating measured	5-point pattern over one square metre of plating. Single measurements on flange

Table 2.4.10.2b : (Contd.)		
Structural member	**Extent of measurement**	**Pattern of measurement**
Hopper structure transverse watertight bulkhead or swash bulkhead	Lower 1/3 of bulkhead	5-point pattern over one square metre of plating
	Upper 2/3 of bulkhead	5-point pattern over two square metre of plating
	Stiffeners (minimum of three)	For web, 5-point pattern over span (two measurements across web at each end and one at centre of span). For flange, single measurements at each end and centre of span
Panel stiffening	Where applicable	Single measurements
Deck structure including cross strips, main cargo hatchways, hatch covers, coamings and topside tanks		
Structural member	**Extent of measurement**	**Pattern of measurement**
Cross deck strip plating	Suspect cross deck strip plating	5 point pattern between underdeck stiffeners over 1 metre length
Underdeck stiffeners	Transverse members	5 point pattern at each end and mid span
	Longitudinal members	5 point pattern on both web and flange
Hatch covers	Side and end skirts, each 3 locations	5 point pattern at each location
	3 longitudinal bands, 2 outboard strakes and centerline strake	5 point measurement each band
Hatch coamings	Each side and end of coaming, one band lower 1/3, one band upper 2/3 of coaming	5 point measurement each band i.e. end or side coaming
Topside ballast tanks	a) watertight transverse bulkheads:	
	- Lower 1/3 of bulkhead	5 point pattern over 1 sq. metre of plating
	- Upper 2/3 of bulkhead	5 point pattern over 1 sq. metre of plating
	- Stiffeners	5 point pattern over 1 metre length
	b) two representative swash transverse bulkheads:	
	- Lower 1/3 of bulkhead	5 point pattern over sq. metre of plating
	- Upper 2/3 of bulkhead	5 point pattern over 1 sq. metre of plating
	- stiffeners	5 point pattern over 1 metre length
	c) three representative bays of slope plating:	
	- Lower 1/3 of tank	5 point pattern over 1 sq. metre of plating
	- Upper 2/3 of tank	5 point pattern over 1 sq. metre of plating
	d) Longitudinals, suspect and adjacent	5 point pattern on both web and flange over 1 metre length

Table 2.4.10.2b (Contd.)		
Structural member	**Extent of measurement**	**Pattern of measurement**
Main deck plating	Suspect plates and four adjacent plates	5 point pattern over 1 sq. metre of plating
Main deck longitudinals	Suspect plates	5 point pattern on both web and flange over 1 metre length
Web frames / transverses	Suspect plates	5 point pattern over 1 sq. metre
Structure in double side spaces of double skin bulk carriers including wing void spaces of ore carriers		
Structural member	**Extent of measurement**	**Pattern of measurement**
Side shell and inner side plating:	a) upper strake and strakes in way of horizontal girders plating between each pair of transverse frames / longitudinals in a minimum of three bays (along the tank)	single measurement
	b) all other strakes plating between every third pair of longitudinals in same three bays	single measurement
Side shell and inner side transverse frames / longitudinals on:	a) upper strake each transverse frame / longitudinal in same three bays	3 measurements across web and 1 measurement on flange
	b) all other strakes every third transverse frame / longitudinal in same three bays	3 measurements across web and 1 measurement on flange
Transverse frames / longitudinals – brackets	Minimum of three at top, middle and bottom of tank in same three bays	5-point pattern over area of brackets
Vertical web and transverse bulkheads:	a) strakes in way of horizontal girders minimum of two webs and both transverse bulkheads	5-point pattern over approx. two square metre area
	b) other strakes minimum of two webs and both transverse bulkheads	two measurements between each pair of vertical stiffeners
Horizontal girders	Plating on each girder in a minimum of three bays	Two measurements between each pair of longitudinal girder stiffeners
Panel stiffening	Where applicable	Single measurements

Table 2.4.10.2b (Contd.)		
Structural member	**Extent of measurement**	**Pattern of measurement**
Transverse bulkheads in cargo holds		
Structural member	**Extent of measurement**	**Pattern of measurement**
Lower stool, where fitted	Transverse band within 25 [mm] of welded connection to inner bottom	5-point pattern between stiffeners over one metre length
	Transverse band within 25 [mm] of welded connection to shelf plate	5-point pattern between stiffeners over one metre length
Transverse bulkheads	Transverse band at approximately mid height	5-point pattern over one square metre of plating
	Transverse band at part of bulkhead adjacent to upper deck or below upper stool shelf plate (for those ships fitted with upper stools)	5-point pattern over one square metre of plating

2.4.10.5 The thickness measurements are to be carried out by a qualified company certified by IRS.

2.4.10.6 In order to ensure necessary control during the process of thickness measurements, these are normally to be carried out under the supervision of the Surveyor. The Surveyor has the right to re-check the measurements as deemed necessary to ensure acceptable accuracy.

2.4.10.7 In all cases the extent of thickness measurements is to be sufficient as to represent the actual average condition.

2.4.10.8 A thickness measurement report is to be prepared. The report is to give the location of measurements, the thickness measured as well as corresponding original thickness. Furthermore, the report is to give the date when the measurements were carried out, type of measuring equipment, names of personnel and their qualifications and has to be signed by the operator. The Surveyor is to review the report of the final thickness measurement after repairs have been carried out and countersign the cover page.

2.4.11 Reporting and evaluation of survey

2.4.11.1 The data and information on the structural condition of the vessel collected during the survey is to be evaluated for acceptability and continued structural integrity of the vessel.

2.4.11.2 For CSR bulk carriers, the ship’s longitudinal strength is to be evaluated by using the thickness of structural members measured, renewed and reinforced, as appropriate, during the special surveys carried out after the ship reached 15 years of age (or during the special survey No.3, if this is carried out before the ship reaches 15 years) in accordance with the criteria for longitudinal strength of the ship’s hull girder for CSR bulk carriers specified in Ch.13 of CSR.

2.4.11.3 The final result of evaluation of the ship’s longitudinal strength required in 2.4.11.2 after renewal or reinforcement work of structural members, if carried out as a result of initial evaluation, is to be reported as a part of the Executive Hull Summary.

2.4.11.4 An Executive Hull Summary of the survey and results is to be issued to the Owner and placed on board the vessel for reference at future surveys. The Executive Hull Summary is to be endorsed by IRS Head Office.

2.4.12 Compliance with IMO standards for scantlings of aft transverse bulkhead of the foremost cargo hold and allowable hold loading for foremost cargo hold

2.4.12.1 These requirements apply to all bulk carriers of 150 [m] in length and above, intending to carry cargoes having bulk density of 1.78 [t/m^3] or above where:

a) The foremost hold is bounded by the side shell only in ships which were contracted for construction prior to 1 July 1998 and

b) The foremost hold is of double skin construction of less than 760 [mm] in breadth, measured perpendicular to the side shell, in ships, the keel of which were laid or were at a similar stage of construction, before 1 July 1999.

2.4.12.2 For existing bulk carriers of the type as mentioned in 2.4.12.1 a) and b) above which have not yet complied with the IMO standards, the compliance is to be achieved within the following time limits:

i) for ships which were 15 years of age or more on 1 July 1998, immediately before continuance in service;

ii) for ships which were 10 years of age or more but less than 15 years of age on 1 July 1998, by the due date of the first intermediate or special survey to be held after the date on which the ship reaches 15 years of age but not later than the date on which the ship reaches 17 years of age;

iii) for ships which were 5 years of age or more but less than 10 years of age on 1 July 1998, on or before the due date, after 1 July 2003, of the first intermediate or special survey after the date on which the ship reaches 10 years of age; and

iv) for ships which were less than 5 years of age on 1 July 1998, on or before the date on which the ship reaches 10 years of age.

Completion prior to 1 July 2003 of an intermediate or special survey with a due date after 1 July 2003, can not be used to postpone compliance.

2.4.12.3 For bulkcarriers described in 2.4.12.2, thickness measurement of vertically corrugated aft transverse bulkhead of the foremost cargo hold is to be carried out to determine the general condition of the structure and to define the extent of possible repairs and/or reinforcements required to meet the above mentioned IMO standards. As a minimum, the thickness measurement is to be carried out at the critical locations given in Table 2.4.12 and Fig.2.4.12.

In addition, thickness measurement is to be carried out at subsequent intermediate surveys (for ships over 10 years of age) and special surveys for the purpose of verifying continuing compliance with the above standards.

Where annual gauging has been adopted as an alternative to steel renewal in accordance with the IMO standards, thickness measurement is also to be carried out at subsequent annual surveys.

2.4.13 Compliance with IACS requirements for existing vessels

2.4.13.1 Compliance with the standards mentioned in Table 2.4.13.1, as applicable, is to be achieved by the due date indicated in 2.4.13.2.

2.4.13.2 Compliance with the requirements indicated in Table 2.4.13.1, as applicable is to be achieved within the following time limits:

i) For ships which will be 15 years of age or more on 1 January 2004 by the due date of the first intermediate or special survey after that date;

ii) For ships which will be 10 years of age or more on 1 January 2004 by the due date of the first special survey after that date;

iii) For ships which will be less than 10 years of age on 1 January 2004 by the date on which the ship reaches 10 years of age.

Completion prior to 1 January 2004 of an intermediate or special survey with a due date after 1January 2004 cannot be used to postpone compliance. However, completion prior to 1 January 2004 of an intermediate survey the window for which straddles 1 January 2004 can be accepted.

2.4.13.3 Ships which are required to comply with UR S31 as indicated in Table 2.4.13.1 are subject to additional thickness measurements with respect to the side shell frames and brackets for the purpose of determining compliance, prior to the due dates as mentioned in 2.4.13.2 and at subsequent intermediate and special surveys for verifying continuing compliance with UR S31.

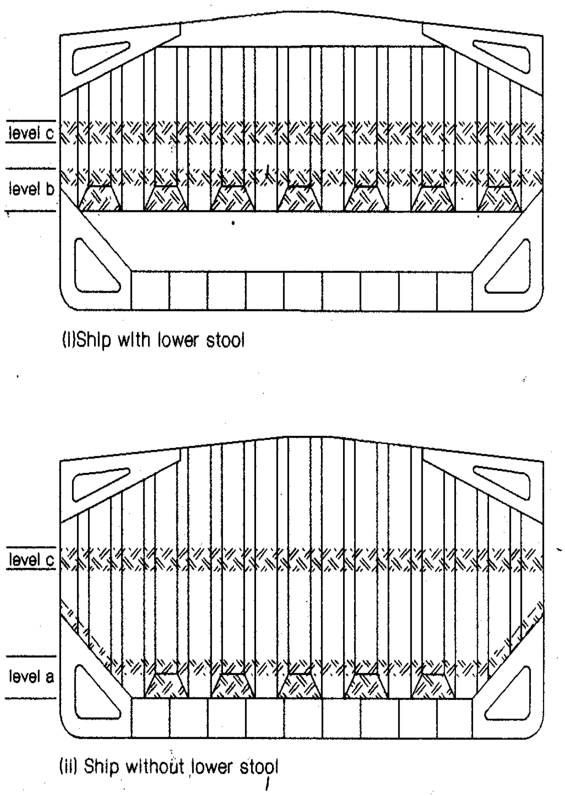

Fig.2.4.12 : Locations for thickness measurement for verification of IMO standard compliance

Table 2.4.12 : Critical levels at which thickness measurement is to be carried out for the vertically corrugated aft transverse bulkhead of the foremost cargo hold of existing bulk carriers to determine compliance with IMO standard	
Level as per Fig.2.4.12	**Locations where thickness is to be measured in Zone 2 (P&S) and Zone 1** **Ships with or without lower stool**
Level (a) OR Level (b)	1) mid breadth of each corrugation flange at about 200 [mm] above line of shedder plates
	2) middle of gusset plates between corrugation flanges, where fitted
	3) middle of each shedder plate
	4) mid breadth of each corrugation web at approximately 200 [mm] above the line of each shedder plate
Level (c)	1) mid breadth of each corrugation flange and web at about the mid-height of the corrugation

Notes:

1. To adequately assess the scantlings of each individual vertical corrugation, each corrugation flange, web, shedder plate and gusset plate within each of the levels given above are to be gauged.
2. Where the thickness changes within the horizontal levels, the thinner plate is to be gauged.
3. Steel renewal/reinforcement is to comply with IMO standard.

2.4.14 Compliance with SOLAS regulation 12, Ch.XII : Hold, ballast and dry space water level detectors

Bulk carriers constructed before 1st July, 2004 are to be fitted with water level detectors as described in Pt.5, Ch.1, 2.13 of the Rules, not later than the date of the annual, intermediate or special survey of the ship to be carried out after 1st July, 2004, whichever comes first.

2.4.15 Compliance with SOLAS regulation 13, Ch.XII : Availability of pumping systems (for dewatering of forward spaces)

Bulk carriers constructed before 1st July, 2004 are to comply with this SOLAS regulation in accordance with details given in Pt.5, Ch.1, 2.14 of the Rules, not later than the date of the first intermediate or special survey of the ship to be carried out after 1st July, 2004, but in no case later than 1st July, 2007.

2.5 Special Surveys – Machinery

2.5.1 Requirements for examination of machinery and piping are given in Sec.8.

Table 2.4.13.1 : Compliance with new IACS unified requirements

Item	Applicable types of vessels	Reference IACS unified requirement	Applicable locations on the ship
Renewal criteria for side shell frames and brackets	Bulk carriers with side frames and/or brackets not meeting the requirements of Pt.5, Ch.1 of the 1998 or subsequent rules	S31	Cargo holds bounded by single side shell
Cargo hatch cover securing arrangements (except for pontoon type hatchcover)	Bulk carriers where cargo hatch covers do not meet the requirements of Pt.3, Ch.12 of the January, 2004 Rules	S30	Securing devices and stoppers for the fore most and the second foremost cargo hold hatchways located wholly or partially within 0.25L of the fore perpendicular
Fore deck fittings: Air pipes and ventilators and their closing devices	Bulk carriers, ore carriers, general dry cargo ships and combination carriers of $L \geq 100$ m contracted for construction prior to 1 January, 2004	S27	Located on the exposed deck and serving spaces wholly or partially forward of the collision bulkhead
Strength of small hatches on the fore deck and their securing devices (See Pt.3, Ch.12, 7.2 for definition of small hatches)	Bulk carriers, ore carriers, general dry cargo ships and combination carriers of $L \geq 100$ m contracted for construction prior to 1 January, 2004.	S26	Located on the exposed deck giving access to spaces wholly or partially forward of the collision bulkhead

Section 3

Surveys - Oil Tankers, Ore or Oil Carriers, Oil or Bulk Carriers

3.1 Scope

3.1.1 This section gives the requirements for periodical surveys of vessels which have been assigned class notations:

Oil Tanker ESP
Ore or Oil Carrier ESP
Oil or Bulk Carrier ESP

3.1.2 For vessels with class notation Ore or Oil Carrier ESP and Oil or Bulk Carrier ESP, the relevant requirements given in Sec.2 are also to be applied.

3.2 Annual surveys

3.2.1 General

3.2.1.1 Annual Surveys are to be carried out within 3 months before or after the anniversary date each year. These should be held concurrently with statutory annual or other relevant statutory Surveys, where practicable.

3.2.1.2 At Annual Surveys, the Surveyor is to examine the hull and machinery, so far as necessary and practicable, in order to be satisfied as to their general condition.

3.2.1.3 Access to cargo tanks or other spaces within the cargo area, necessitating gas freeing will normally not be required unless necessary for checking items of equipment and installations for correct functioning.

3.2.1.4 It is to be confirmed that no new installation of material containing asbestos was carried out since last survey.

3.2.2 Hull and weather deck

3.2.2.1 The survey is to consist of an examination for the purpose of ensuring, as far as practicable, that the hull, equipment, closing appliances and related piping are maintained in satisfactory and efficient condition. Special attention is to be paid to the following:

a) Weather deck, ship side plating above water line.

b) Openings on freeboard and superstructure decks; exposed casings; skylights and fiddley openings; deck houses; companionways and superstructure bulkheads; side scuttles and dead lights; flush deck scuttles; ash shoots and other openings.

c) Weld connection between air pipes and deck plating; air pipe heads on exposed decks (external examination); ventilators and closing devices.

d) Watertight bulkheads and their penetrations as far as practicable.

e) Scuppers and sanitary discharges as far as practicable together with valves and their controls.

f) Guard rails, bulwarks, freeing ports, gangways, walkways and life lines.

g) Cargo tank openings including gaskets, covers, coamings and flame screens.

h) Cargo tanks pressure/vacuum valves, secondary means to prevent over or under pressure and devices to prevent passage of flame.

i) Flame screens on vents to all bunker tanks.

j) Examination of cargo, crude oil washing, bunker and vent piping systems, including vent masts and headers.

3.2.2.2 Examination of pump room and pipe tunnel, if fitted, is to be carried out including:

a) Examination of all pump room bulkheads for signs of oil leakage or fractures and, in particular, the sealing arrangements of all penetrations of pump room bulkheads.

b) Examination of the condition of all piping systems.

3.2.2.3 All watertight doors in watertight bulkheads, to be examined and tested (locally and remotely) as far as practicable.

3.2.2.4 Suspect areas identified at previous special or intermediate surveys are to be close-up surveyed. Thickness measurements are to be taken in the area of substantial corrosion identified at previous surveys.

3.2.2.5 Examination of Ballast Tank is to be carried out when required as a consequence of the results of the Special Survey or Intermediate Survey. (See 3.4.5.1 and 3.3.3.3 respectively). When considered necessary by the Surveyor or where extensive corrosion is found, thickness measurement is to be carried out. When examination of ballast tanks reveals substantial corrosion, additional thickness measurements are to be carried out to the extent given in Table 3.4.9.2a) or Table 3.4.9.2b).

For vessels built under IACS Common Structural Rules, the identified substantial corrosion areas are required to be examined and additional thickness measurements are to be carried out.

3.2.2.6 Anchoring and mooring equipment is to be examined as far as is practicable. A general examination of emergency towing arrangements is to be carried out to ensure their ready availability.

For vessels with single point mooring arrangements where 'SPM' notation is assigned, the following are to be generally examined:

a) Components of the single point mooring system (bow chain stoppers, bow fairleads, pedestal roller fairleads, winches and capstans), to verify their satisfactory condition.

b) Hull structures supporting and adjacent to the components of the single point mooring system, to verify that there is no deformation or fracture.

3.2.2.7 Where applicable Surveyor should satisfy himself regarding the freeboard marks on the ship's side.

3.2.2.8 The Surveyor is to confirm that, where required, an approved loading instrument together with its operation manual are available on board, See Pt.3, Ch.5. It is to be verified by the Surveyor that the loading instrument is checked for accuracy at regular intervals by the ship's staff by applying test loading conditions.

3.2.2.9 Accommodation ladders are to be examined at annual surveys. Satisfactory condition of the following items is to be checked, in particular :

a) steps;
b) platforms;
c) all support points such as pivots, rollers, etc.;
d) all suspension points such as lugs, brackets, etc.;
e) stanchions, rigid handrails, hand ropes and turntables;
f) davit structure, wire and sheaves, etc.

3.2.2.10 Gangways are to be examined at annual surveys. Satisfactory condition of the following items is to be checked, in particular :

a) treads;
b) side stringers, cross-members, decking, deck plates, etc.;
c) all support points such as wheel, roller, etc.;
d) stanchions, rigid handrails, hand ropes.

3.2.2.11 Winches of accommodation ladders and gangways are to be examined to verify the satisfactory condition of the following items:

a) brake mechanism including condition of brake pads and band brake, if fitted;
b) remote control system, and
c) power supply system for electric motor.

3.2.2.12 Davits and fittings on the ship’s deck associated with accommodation ladders and gangways are to be examined for satisfactory condition at annual surveys. Fittings or structures for means of access to deck such as handholds in a gateway or bulwark ladder and stanchions are also to be examined.

3.2.2.13 The maintenance and inspection records of accommodation ladders and gangways are to be verified. It is to be confirmed that supporting wires are being renewed at intervals not exceeding 5 years.

3.2.2.14 When examining internal spaces, as far as practicable, the permanent means of access where appropriate, are to be verified that they remain in good condition.

3.2.2.15 For vessels subject to IMO PSPC (See Pt.3, Ch.2, 3.6) it is to be confirmed that the maintenance, repair and partial re-coating of dedicated ballast tanks when appropriate are recorded in the coating technical file.

3.2.3 Machinery and systems

3.2.3.1 A general examination of the machinery, boilers, all pressurised systems (steam, pneumatic, hydraulic) and their associated fittings, propulsion system and auxiliary machinery to see whether they are being properly maintained and with particular attention to the fire and explosion hazards.

3.2.3.2 Confirmation that machinery, boilers and other pressure vessels, associated piping systems and fittings are so installed and protected as to reduce to a minimum any danger to persons on board, due regard being given to moving parts, hot surfaces and other hazards.

3.2.3.3 Confirmation that Periodical Surveys of boilers and other pressure vessels have been carried out as required by the Rules and the safety devices have been tested.

3.2.3.4 Confirmation that the normal operation of the propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative.

3.2.3.5 Confirmation that means are provided so that machinery can be brought into operation from the dead ship condition without external aid.

3.2.3.6 All main and auxiliary steering arrangements and their associated equipment and control systems are to be examined and tested. Where applicable, Surveyors are to verify that log entries have been made in accordance with statutory requirements.

3.2.3.7 Confirming, when appropriate, that requisite arrangements to regain steering capability in the event of the prescribed single failure are being maintained.

3.2.3.8 Steering chains are to be cleaned for ascertaining wear and tear and lengths of chain worn in mean diameter by more than 12 per cent of the original rule diameter are to be renewed.

3.2.3.9 All the means of communication between the navigating bridge and the machinery control positions, as well as the bridge and the main alternative steering position, if fitted, are to be tested. It is to be confirmed that means of indicating the angular position of the rudder are operating satisfactorily.

3.2.3.10 Confirmation that with ships having emergency steering positions there are means of relaying heading information and, when appropriate, supplying visual compass readings to the emergency steering positions.

3.2.3.11 Confirmation that various alarms required for hydraulic power operated, electric and electro-hydraulic steering gears are, operating satisfactorily and that the recharging arrangements for hydraulic power operated steering gears are being maintained.

3.2.3.12 Examining the means for the operation of the main and auxiliary machinery essential for propulsion and the safety of the ship, including when applicable, the means of remotely controlling the propulsion machinery from the navigating bridge and the arrangements to operate the main and other machinery from a machinery control room.

3.2.3.13 Confirmation that the engine room telegraph, the second means of communication between the navigation bridge and the machinery space and the means of communication with any other positions from which the engines are controlled are operating satisfactorily.

3.2.3.14 Confirmation that the engineer's alarm is clearly audible in the engineer's accommodation.

3.2.3.15 The bilge pumping systems and bilge wells including operation of each bilge pump, extended spindles and level alarms, where fitted, are to be examined as far as is practicable. It is also to be confirmed that bilge pumping system for each watertight compartment is satisfactory.

It is also to be confirmed that drainage from enclosed cargo spaces situated on freeboard deck is satisfactory.

3.2.3.16 Examining visually the condition of any expansion joints in sea water system.

3.2.3.17 General examination visually and in operation, as feasible, of the main electrical machinery, the emergency sources of electrical power, the switch gear, other electrical equipment including the lighting system is to be carried out.

3.2.3.18 Confirmation as far as practicable, the operation of the emergency source(s) of electrical power, including their starting arrangement, the systems supplied, and when appropriate, their automatic operation.

3.2.3.19 Examining in general, that the precautions provided against shock, fire and other hazards of electrical origin are being maintained.

3.2.3.20 General Examination of automation equipment is to be carried out. Satisfactory operation of safety devices, bilge level detection and alarm systems and control systems is to be verified.

3.2.3.21 Confirmation that machinery space ventilation systems are in good working condition.

3.2.3.22 Examination so far as is possible of cargo, bilge, ballast and stripping pumps for excessive gland seal leakage, verification of proper operation of electrical and mechanical remote operating and shutdown devices and operation of pump room bilge system, and checking that pump foundations are intact.

3.2.3.23 Checking the protection of cargo pump room and in particular:

a) Checking temperature sensing devices for bulkhead glands and alarms;

b) Checking interlock between lighting and ventilation.

c) Checking gas detection system.

d) Checking bilge level monitoring devices and alarms.

3.2.3.24 Verification that installed pressure gauges on cargo discharge lines and level indicating systems are operational.

3.2.3.25 Examination of emergency lighting in all cargo pump rooms of tankers constructed after 1 July 2002.

3.2.4 Fire protection, detection and extinction

3.2.4.1 The arrangements for fire protection, detection and extinction are to be examined and are to include confirmation that no changes have been made in the structural fire protection. Following are to be examined / verified:

a) verification that fire control plans are properly posted;

b) examination as far as possible and testing as feasible of the fire and/or smoke detection system(s);

c) examination of the fire main system and verification that each fire pump including the emergency fire pump can be operated separately so that the two required powerful jets of water can be produced simultaneously from different hydrants;

d) verification that fire hoses, nozzles, applicators and spanners are in good working condition and situated at their respective locations;

e) examination of fixed fire fighting system controls, piping, instructions and marking, checking for evidence of proper maintenance and servicing including date of last systems tests;

f) verification that all semi-portable and portable fire extinguishers are in their stowed positions, checking for evidence of proper maintenance and servicing, conducting random check for evidence of discharged containers;

g) verification, as far as practicable, that the remote controls for stopping fans and machinery and shutting off fuel supplies in machinery spaces are in working order;

h) examination of the closing arrangements of ventilators, funnel annular spaces, skylights, doorways and tunnel, where applicable;

i) confirmation that the fire fighters' outfits and emergency escape breathing devices (EEBDS) are complete and in good condition and that the cylinders, including the spare cylinders, of any required self-contained breathing apparatus are suitably charged;

j) examination of any manual and automatic fire doors and proving their operations;

k) verification that the pump room ventilation system is operational, ducting intact, dampers operational and screens are clean;

l) external examination of piping and cut-out valves of cargo tank and cargo pump room fixed fire fighting system;

m) verification that the deck foam system and deck sprinkler system are in good operating condition so far as is practicable;

n) verification that all electrical equipment in dangerous zones is in good condition and has been properly maintained so far as is practicable;

o) checking the deck foam system, including the supplies of foam concentrate and testing that minimum number of jets of water at the required pressure in the fire main is obtained when the system is in operation;

p) examination of the fire-extinguishing systems for spaces containing paint and/or flammable liquids and deep fat cooking equipment in accommodation and service spaces;

q) examination of the fire safety requirements of any helicopter facilities.

Surveys carried out by the National Authority of the country in which the ship is registered would normally be accepted as meeting these requirements, at the discretion of the Surveyor.

3.2.4.2 For tankers fitted with inert gas system, examination of the inert gas system as detailed in Section 12, Para 12.2.1 is to be carried out.

3.2.4.3 Confirmation that the means of escape from accommodation, machinery spaces and other spaces are satisfactory.

3.2.4.4 Examination of the arrangements for gaseous fuel for domestic purposes.

3.3 Intermediate Surveys

3.3.1 General

3.3.1.1 Intermediate surveys are to be carried out at or between the second or third Annual Survey. However, only those items which are additional to the requirements of annual survey may be examined between the second or third annual survey.

Concurrent crediting to both Intermediate survey and Special survey for surveys and thickness measurements of spaces is not acceptable.

3.3.1.2 The following requirements are applicable for vessels over five years of age. For vessels below 5 years of age additional examination over and above the requirements of Annual survey may be required at the discretion of the Surveyors.

3.3.1.3 For vessels over 10 years of age a specific survey program is to be worked out by the owner in cooperation with the Surveyors considering the requirements of the previous special survey, executive hull summary of that survey, later relevant survey records and taking account of any amendments to the survey requirements after the last special survey. The survey program is to be submitted in written format for approval and kept on board until the intermediate survey has been completed. (See 3.4.2 for guidance on preparation of survey program).

3.3.1.4 Prior to the commencement of any part of the intermediate survey, a survey planning meeting is to be held between the attending Surveyor(s), the owner's representative in attendance and where involved, the thickness measurement company representative and the master of ship or an appropriately qualified representative appointed by the master or Company for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

3.3.2 Examination and testing

3.3.2.1 The following are to be carried out:

a) The survey to the extent specified in 3.3.3 to 3.3.5 depending on the age and type of the tanker.

b) For weather decks, an examination as far as applicable of cargo, crude oil washing, bunker, ballast, steam and vent piping systems as well as vent masts and headers. If upon examination there is any doubt as to the condition of the piping, the piping may be required to be pressure tested, thickness measured or both.

c) For vessels built under IACS Common Structural Rules, the identified substantial corrosion areas are required to be examined and additional thickness measurements are to be carried out.

d) A general examination of electrical equipment in dangerous zones and testing of insulation resistance of the circuits. In cases where a proper record of testing is maintained, consideration may be given to accepting recent readings. These measurements are not to be attempted until the ship is in gas free condition and are to be carried out within an acceptable time period.

3.3.3 Oil tankers between 5 and 10 years of age

3.3.3.1

a) Single hull oil tankers:

All ballast tanks are to be examined. When considered necessary by the Surveyor, thickness measurement and testing are to be carried out to ensure that the structural integrity remains effective.

b) Double hull oil tankers:

For tanks used for water ballast, an Overall Survey of Representative Tanks selected by the Surveyor is to be carried out. If such inspections reveal no visible structural defects, the examination may be limited to a verification that the hard Protective Coating remains in GOOD condition.

3.3.3.2 In addition to the requirements above, suspect areas identified at previous surveys are to be close-up surveyed.

3.3.3.3 A ballast tank is to be examined at subsequent annual intervals where:

a) a hard protective coating has not been applied from the time of construction, or

b) a soft or semi-hard coating has been applied, or

c) substantial corrosion is found within the tank, or

d) the hard protective coating is found to be in less than GOOD condition and the hard protective coating is not repaired to the satisfaction of the Surveyor.

3.3.4 Oil tankers between 10 and 15 years of age

3.3.4.1 The requirements of the intermediate survey are to be to the same extent as the previous special survey as required in 3.4 for hull structure and piping systems in way of cargo tanks, pump rooms, cofferdams, pipe tunnels, void spaces within the cargo area and all ballast tanks. However, pressure testing of cargo and ballast tanks, survey of automatic air pipe heads and specified in 3.4.6.10 and the requirements for longitudinal strength evaluation of hull girder required in 3.4.10.2 are not required unless deemed necessary by the attending surveyor. Thickness measurement is to be carried out for items 1) to 4) of Table 3.4.9.1.

3.3.4.2 The intermediate survey may be commenced at the second annual survey and be progressed during the succeeding year with a view to completion by the third annual survey in lieu of the application of 3.4.1.4.

3.3.4.3 An in-water survey complying with the requirements of Sec.7.2 may be accepted in lieu of the requirements of 3.4.1.9.

3.3.5 Oil tankers exceeding 15 years of age the following is to apply:

3.3.5.1 The requirements of the intermediate survey are to be to the same extent as the previous special survey as required in 3.4 for hull structure and piping systems in way of cargo tanks, pump rooms, cofferdams, pipe tunnels, void spaces within the cargo area and all ballast tanks. However, pressure testing of cargo and ballast tanks, survey of automatic air pipe heads as specified in 3.4.6.10 and the longitudinal strength evaluation of hull girder required in 3.4.10.2 need not be carried out unless deemed necessary by the attending surveyor. Thickness measurement is to be carried out for items 1) to 4) of Table 3.4.9.1.

3.3.5.2 The intermediate survey may be commenced at the second annual survey and be progressed during the succeeding year with a view to completion by the third annual survey in lieu of the application of 3.4.1.4.

3.3.5.3 A survey in dry dock is to be part of the intermediate survey. Any remaining work in respect of the overall and close-up surveys and thickness measurements and repairs applicable to the lower portions of cargo tanks and ballast tanks (i.e. parts below light ballast water line) are to be completed in the dry-dock.

3.4 Special Surveys - Hull

3.4.1 General

3.4.1.1 All ships classed with IRS are to undergo Special Surveys at 5 yearly intervals. The first Special Survey is to be completed within 5 years from the date of the initial classification survey and thereafter 5 years from the assigned date of the previous Special Survey. However, an extension of class of 3 months maximum beyond the 5th year may be granted in exceptional circumstances in accordance with 1.11. In such cases, the next period of class will start from the expiry date of the Special Survey before extension was granted.

3.4.1.2 The interval between the Special Surveys may be reduced at the request of the parties concerned or by IRS if considered appropriate.

3.4.1.3 For surveys completed within 3 months before the expiry date of the Special Survey, the next period of class will start from the expiry date of the Special Survey. For surveys completed more than 3 months before the expiry date of the Special Survey, the period of class will start from the survey completion date. In cases where the vessel has been laid up or has been out of service for a considerable period because of a major repair or modification and the owner elects to only carry out the overdue surveys, the next period of class will start from the expiry date of the special survey. If the owner elects to carry out the next due special survey, the period of class will start from the survey completion date. Any requirement of the Flag Administration in this regard is also to be complied with.

3.4.1.4 The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date. When the special survey is commenced prior to the fourth annual survey, the entire survey is to be completed within 15 months if such work is to be credited to the special survey and in this case the next period of class will start from the survey completion date.

Concurrent crediting to both Intermediate survey and Special survey for surveys and thickness measurements of spaces is not acceptable.

3.4.1.5 As part of the preparation for Special Survey, the proposed Survey Programme (See 3.4.2) including the schedule for thickness measurements (See 3.4.9) are to be submitted in advance of the Special Survey.

3.4.1.6 Record of Special Survey will not be assigned until the Machinery Survey has been completed or postponed in agreement with IRS.

3.4.1.7 Ships which have satisfactorily passed a Special Survey will have a record entered in the Supplement to the Register Book indicating the assigned date of Special Survey. In addition a notation "ESP" will be entered for oil tankers.

3.4.1.8 The special survey is to include, in addition to the requirements of the Annual Survey, examination, tests and checks of sufficient extent to ensure that the hull, equipment and related piping are in satisfactory condition and that the ship is fit for its intended purpose for the next five (5) year class period, subject to proper maintenance and operation and the periodical surveys being carried out at the due dates.

A Docking Survey in accordance with the requirements of Sec.7 is to be carried out as part of the Special Survey. Any remaining work in respect of the overall and close-up surveys and thickness measurements and repairs applicable to the lower portions of cargo tanks and ballast tanks (i.e. parts below light ballast water line) are to be completed in the dry-dock.

3.4.2 Planning and preparation for survey

3.4.2.1 A specific Survey Programme is to be worked out in advance of the Survey by the Owner in cooperation with the Surveyors and submitted to IRS for approval. The Survey Programme is to be in a written format based on IMO Resolution MSC197(80). The survey is not to commence until the survey programme has been agreed. Prior to the development of the survey programme, the survey planning questionnaire based on IMO Resolution MSC197(80) is to be completed by the owner and forwarded to IRS. The Survey Programme at Intermediate Survey may consist of the Survey Programme at the previous Special Survey supplemented by the Executive Hull Summary of that Special Survey and later relevant survey reports. The survey program is to be worked out taking into account any amendments to the survey requirements after the last special survey.

3.4.2.2 In developing the Survey Programme, the following documentation is to be collected and consulted with a view to selecting tanks, areas and structural areas for examination :

a) Survey status and basic ship information;

b) Documentation on board as per 3.4.3;

c) Main structural plans (scantling drawings), including information regarding use of high strength steels, clad steel and stainless steel;

d) Executive Hull Summary;

e) Relevant previous damage and repair history;

f) Relevant previous survey and inspection reports of IRS and the Owners;

g) Cargo and ballast history for the last 3 years, including carriage of cargo under heated conditions;

h) Details of the inert gas plant and tank cleaning procedures;

i) Information and other relevant data regarding conversion or modification of the ship’s cargo and ballast tanks since the time of construction.

j) Description and history of the coating and corrosion protection system (including previous class notations), if any;

k) Inspections by the Owner's personnel during the last 3 years with reference to structural deterioration in general, leakages in tank boundaries and piping and condition of the coating and corrosion protection system if any;

l) Information regarding the relevant maintenance level during operation including port state control reports of inspection containing hull related deficiencies. Safety Management System non-conformities relating to hull maintenance, including the associated corrective action(s); and

m) Any other information that will help identify suspect areas and critical structural areas.

3.4.2.3 The Survey Programme submitted for approval is to account for and comply, as a minimum, with the requirements of close-up survey, thickness measurement and tank testing respectively, and to include relevant information including at least :

a) Basic ship information and particulars;

b) Main structural plans (scantling drawings), including information regarding use of high strength steels, clad steel and stainless steel;

c) Plan of tanks;

d) List of tanks with information on use, extent of coatings and corrosion protection systems;

e) Conditions for survey (e.g. information like tank cleaning, gas freeing, ventilation, lighting, etc.);

f) Provisions and methods of access to structures;

g) Equipment for survey; and

h) Identification of tanks and areas for close-up survey (As per Table 3.4.8.1a or Table 3.4.8.1b)

i) Identification of sections for thickness measurement (As per Table 3.4.9.1)

j) Identification of tanks for testing

k) Identification of the thickness measurement company.

l) Damage experience related to the ship in question.

m) Critical structural areas and suspect areas, where relevant.

3.4.2.4 IRS will advise the Owner of the maximum acceptable structural corrosion diminution levels applicable to the vessel.

3.4.2.5 The ship is to be prepared for overall survey in accordance with the requirements of Table 3.4.2.5. The preparation is to be of sufficient extent to facilitate an examination to ascertain any excessive corrosion, deformation, fractures, damages and other structural deterioration.

3.4.2.6 Proper preparation and the close co-operation between the attending surveyor(s) and the owner's representatives onboard prior to and during the survey are an essential part in the safe and efficient conduct of the survey. During the survey on board safety meetings are to be held regularly

3.4.2.7 Prior to commencement of any part of the special survey, a survey planning meeting is to be held between the attending surveyor(s), the owner's representative in attendance, the thickness measurement company representative and the master of the ship or an appropriately qualified representative appointed by the master or Company for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

3.4.2.8 The following is an indicative list of items that are to be addressed in the meeting:

a) Schedule of the vessel (i.e. the voyage, docking and undocking manoeuvres, periods alongside, cargo and ballast operations, etc.);

b) Provisions and arrangements for thickness measurements (i.e. access, cleaning/de-scaling, illumination, ventilation, personal safety);

c) Extent of the thickness measurements;

d) Acceptance criteria (refer to the list of minimum thicknesses);

e) Extent of close-up survey and thickness measurement considering the coating condition and suspect areas/areas of substantial corrosion;

f) Execution of thickness measurements;

g) Taking representative readings in general and where uneven corrosion / pitting is found;

h) Mapping of areas of substantial corrosion; and

Communication between attending surveyor(s) the thickness measurement company operator(s) and owner representative(s) concerning findings.

Table 3.4.2.5 : Survey preparation

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequently** **Age > 15**
1) All tanks, peaks, bilges and drain wells, engine and boiler spaces and other spaces are to be cleared out and cleaned as necessary for examination. Floor plates in engine and boiler spaces are to be lifted as may be necessary for examination of the structure underneath. Where necessary ceiling, lining, casings and loose insulation are to be removed as required by the Surveyor for examination of the structure. Compositions on the plating are to be examined and sounded, but need not be disturbed if found satisfactorily adhering to the plating 2) The steelwork is to be exposed and cleaned as may be required for its proper examination by the Surveyor and close attention is to be paid to the parts of the structure which are particularly liable to excessive corrosion or to deterioration due to other causes. 3) All tanks are to be cleaned as necessary to permit examination. 4) Casings or covers of air, sounding, steam and other pipes, spar ceiling and lining in way of the side scuttles are to be removed, as required by the Surveyor.	1) Requirements of Special Survey I to be complied with 2) The chain locker is to be cleaned internally. The chain cables are to be ranged for inspection. The anchors are to be cleaned and placed in an accessible position for inspection.	1) Requirements of Special Survey II to be complied with 2) Portions of wood sheathing, or other covering, on steel decks are to be removed, as considered necessary by the Surveyor, in order to ascertain the condition of the plating.	1) Requirements of Special survey III to be complied with

3.4.3 Documentation on board

3.4.3.1 The Owners are to obtain supply and maintain on board documentation as specified in 3.4.3.3, which is to be readily available for the Surveyor.

3.4.3.2 The documentation is to be kept on board for the life time of the ship.

3.4.3.3 A Survey Report File is to be a part of the documentation on board consisting of

- Reports of structural surveys
- Executive Hull Summary
- Thickness measurement reports.

3.4.3.4 The Survey Report File is to be available also in the Owners management offices and with IRS.

3.4.3.5 The following additional supporting documentation is to be available on board:

- Main structural plans of cargo and ballast tanks (for CSR ships these plans are to include for each structural element both the as-built and renewal thickness. Any thickness for voluntary addition is also to be clearly indicated on the plans. The midship section plan to be supplied on board the ship is to include the minimum allowable hull girder sectional properties for the tank transverse section in all cargo tanks)
- Previous repair history
- Cargo and ballast history
- Extent of use of inert gas plant and tank cleaning procedures
- Inspection by ship's personnel with reference to
  - structural deterioration in general
  - leakages in bulkheads and piping
  - condition of coating or corrosion prevention system, if any
- Any other information that will help identify critical structural areas and/or Suspect Areas requiring inspection.
- Survey Programme as required by 3.4.2 until such time as the Special Survey has been completed.

3.4.3.6 Prior to survey, the Surveyor is to examine the completeness of the documentation on board, and its contents as a basis for the survey.

3.4.4 Surveys at sea or at anchorage

3.4.4.1 See Sec.1.8.

3.4.5 Space protection

3.4.5.1 Where provided, the condition of coating or corrosion protection of cargo tanks and ballast tanks is to be examined.

A ballast tank is to be examined at subsequent annual intervals where:

a) a hard protective coating has not been applied from the time of construction, or

b) a soft or semi-hard coating has been applied, or

c) substantial corrosion is found within the tank, or

d) the hard protective coating is found to be in less than GOOD condition and the hard protective coating is not repaired to the satisfaction of the Surveyor.

3.4.5.2 Where the hard protective coating in tanks is found to be in GOOD condition, the extent of close-up surveys and thickness measurements may be specially considered.

3.4.6 Survey and examination

3.4.6.1 All spaces within the hull and superstructure are to be examined.

3.4.6.2 All tanks other than cargo and water ballast tanks are to be examined internally in accordance with the requirements of Table 3.4.6.2.

3.4.6.3 An overall survey of all cargo tanks, ballast tanks including double bottom tanks, pipe tunnels, cofferdams and void spaces bounding cargo tanks, decks and outer hull is to be carried out. This examination is to be supplemented by thickness measurement and testing as required by 3.4.9 and 3.4.7 to ensure that the structural integrity remains effective. The aim of the examination is to discover Substantial

Corrosion, significant deformation, fractures, damages or other structural deterioration and if deemed necessary by the Surveyor, a suitable non-destructive examination may be required.

3.4.6.4 Cargo piping on deck including crude oil washing (COW) piping and cargo and ballast piping systems within the above tanks and spaces are to be examined and operationally tested to working pressure to attending Surveyor's satisfaction to ensure that tightness and condition remain satisfactory. Special attention is to be given to ballast piping in cargo tanks and cargo piping in Ballast Tanks and void spaces and Surveyors are to be advised on all occasions when the piping, including valves and fittings are open during repair periods and can be examined internally.

3.4.6.5 Where ballast tanks have been converted to void spaces, the survey extent is to be based upon ballast tank requirements.

3.4.6.6 All watertight bulkheads and watertight doors are to be examined. All decks, casings and superstructures are to be examined. Attention is to be given to the corners of openings and other discontinuities in way of the strength decks and top sides.

3.4.6.7 The masts, standing rigging and anchors are to be examined.

The Surveyor should satisfy himself that there are sufficient mooring ropes on board and also that a tow line is provided when this is a Rule requirement.

3.4.6.8 The steering gear, and its connections and control systems (main and alternative) are to be examined. The auxiliary steering gear with its various parts are to be examined in working condition.

3.4.6.9 The hand pumps and suctions, air and sounding pipes are to be examined. The Surveyors are to ensure that striking plates are fitted under the sounding pipes whilst examining the tanks internally.

Automatic air pipe heads are to be internally examined at special surveys as indicated in Table 3.4.6.10. For designs where the inner parts cannot be properly inspected from outside, the head is to be removed from the air pipe. Particular attention is to be paid to the condition of the zinc coating in heads constructed from galvanised steel.

Table 3.4.6.2 : Requirements for internal examination of tanks

Tank	**Special Survey No. I Age ≤ 5**	**Special Survey No. II 5 < Age ≤ 10**	**Special Survey No. III 10 < Age ≤ 15**	**Special Survey No. IV and subsequent Age > 15**
Fuel oil bunker tanks - Engine room - Other area	 None None	 None One	 One Two	 One Half the number of tanks, minimum 2
Lub.oil	None	None	None	One
Fresh water	None	One	All	All

Notes:

1) These requirements apply to tanks of integral (structural) type.

2) If a selection of tanks is accepted to be examined, then different tanks are to be examined at each special survey, on a rotational basis.

3) Peak tanks (all uses) are subject to internal examination at each special survey.

4) At special survey No.III and subsequent special surveys, one deep tank for fuel oil is to be included, if fitted.

3.4.6.10 The Surveyor should satisfy himself regarding the efficient condition of the following :

- Means of escape from machinery spaces, crew and passenger spaces and spaces in which crew are normally employed;

- Means of communication between bridge and engine room and between bridge and alternative steering position;

- Helm indicator;

- Protection to the aft steering wheel and the gear.

3.4.6.11 The chain cables are to be ranged and the anchors and the chain cables are to be examined. At special survey no. II and subsequent special surveys, the chain cables are to be gauged. Any length of chain cable which is found to have reduced in mean diameter at its most worn part by more than 12 per cent of its original rule diameter is to be renewed.

3.4.6.12 The windlass is to be examined.

3.4.6.13 A thorough examination of aft and forward emergency towing arrangements is to be carried out to ensure its ready availability and satisfactory condition.

- examination of pick-up gear, towing pennant and chafing gear for possible deterioration;

- examination of strong points, fairleads, pedestal roller and their attachment to hull structure.

The survey is to confirm that one of the towing arrangements (aft or forward) are pre-rigged.

3.4.6.14 For vessels with single point mooring arrangements where 'SPM' notation is assigned, the following is to be carried out:

a) A thorough examination of the components of the single point mooring system (bow chain stoppers, bow fairleads, pedestal roller fairleads, winches and capstans) to verify their satisfactory condition.
b) A close-up examination of the hull structures supporting and adjacent to the components of the single point mooring system to verify that there is no deformation or fracture. Thickness determination and non-destructive tests are to be carried out if required by the Surveyor.

3.4.6.15 The chain locker, hold fasts, hawse pipes and chain stoppers are to be examined and pumping arrangements of the chain locker tested.

Table 3.4.6.10 : Requirements for internal examination of automatic air pipe heads

Location	Special survey No.I Age ≤ 5	Special survey No.II 5 < Age ≤ 10	Special survey No.III and subsequent Age > 10
forward 0.25L	Two air pipe heads[1,2] one port and one starboard on exposed decks	All air pipe heads on exposed decks	All air pipe heads[3] on exposed decks
aft of 0.25L from the forward perpendicular	Two air pipe heads[1,2] one port and one starboard on exposed decks	At least 20% of air pipe heads[1,2] on exposed decks	

Notes:

1. Preferably air pipes serving ballast tanks.
2. The selection of air pipe heads is to be made by the attending Surveyor. According to the results of the inspection, the Surveyor may require additional air pipe heads to be examined.
3. When there is substantiated evidence of replacement within the previous five years, individual air pipe heads may not be examined.

3.4.6.16 Engine room structure is to be examined. Particular attention being given to tank tops, shell plating in way of tank tops, brackets connecting side shell frames and tank tops and engine room bulkheads in way of tank tops and bilge wells. Where excessive areas of wastage are found, thickness measurements are to be carried out and renewals of repairs made when wastage exceeds allowable limits.

3.4.6.17 The attachment to the structure and condition of anodes in tanks is to be examined.

3.4.6.18 Where fitted, the strums of the cargo suction pipes are to be removed or lifted to facilitate examination of the shell plating and bulkheads in the vicinity, unless other means for visual inspection of these parts are provided.

3.4.6.19 The loading instrument is to be checked for accuracy by applying test load conditions in presence of the Surveyor.

3.4.6.20 Examination of accommodation ladders, gangways and their winches are to be carried out as required for annual surveys. In addition, the accommodation ladders and gangways are to be operationally, tested with the specified maximum operation load.

The tests are to be carried out with the load applied as uniformly as possible along the length of the accommodation ladder or gangway, at an angle of inclination corresponding to the maximum bending moment on the accommodation ladder or gangway.

Accommodation ladder winch is to be operationally tested at special surveys. The brake system of the winch is to be tested for holding the maximum operational load on the ladder.

For existing installations on board ships constructed prior to 01 Jan 2010 where the maximum operational load is not known, load nominated by the shipowner or operator may be considered as the test load.

3.4.7 Extent of tank testing

3.4.7.1 The minimum requirements for tank testing for oil tankers (including ore/oil and ore/bulk/oil ships) in the cargo area are given in Table 3.4.7.1.

3.4.7.2 All double bottom and peak tanks are to be tested in addition. The Surveyor may extend the tank testing as deemed necessary.

3.4.7.3 Boundaries of ballast tanks are to be tested with a head of liquid to the top of air pipes. Boundaries of cargo tanks are to be tested to the highest point that liquid will rise under service conditions.

Table 3.4.7.1 : Table of minimum requirements for tank testing at special survey of oil tankers, ore/oil ships and ore/bulk/oil ships (including double hull oil tankers)

Special Survey No. I Age ≤ 5	Special Survey No. II and subsequent Age > 5
1 All ballast tank boundaries	1 All ballast tank boundaries
2 Cargo tank boundaries facing ballast tanks, void spaces, pipe tunnels, pump rooms or cofferdams	2 All Cargo tank bulkheads

3.4.7.4 Boundaries of fuel oil, lub.oil and fresh water tanks are to be tested with a head of liquid to the highest point that liquid will rise under service conditions. Tank testing of fuel oil, lub.oil and fresh water tanks may be specially considered based on a satisfactory external examination of the tank boundaries and a confirmation from the Master stating that the pressure testing has been carried out according to the requirement with satisfactory results

3.4.7.5 For double hull oil tankers the testing of double bottom tanks and other spaces not designed for the carriage of liquid may be omitted, provided a satisfactory internal examination together with an examination of the tank top is carried out.

3.4.7.6 Cargo tank testing carried out by the vessel's crew under the direction of the Master may be accepted by the surveyor subject to the approval of the Administration, provided the following conditions are complied with:

a) a tank testing procedure, specifying fill heights, tank being filled and bulkheads being tested, taking into account the guidelines provided in the ESP Planning document, has been submitted by the owner and reviewed by IRS prior to the testing being carried out;

b) there is no record of leakage, distortion or substantial corrosion that would affect the structural integrity of the tank;

c) the tank testing has been satisfactorily carried out, in accordance with the reviewed procedure and the guidelines mentioned in a) above, within special survey window not more than 3 months prior to the date of the survey on which the overall or close up survey is completed;

d) the satisfactory results of the testing is recorded in the vessel's logbook;

e) the internal and external condition of the tanks and associated structure are found satisfactory by the surveyor at the time of the overall and close up survey.

3.4.8 Close-up survey requirements

3.4.8.1 The minimum requirements for Close-up Surveys at Special Survey are given in Table 3.4.8.1a and Table 3.4.8.1b as applicable.

3.4.8.2 The Surveyor may extend the Close-up Survey as deemed necessary taking into account the maintenance of the tanks under survey, the condition of the corrosion prevention system and also in the following cases:

a) In particular, tanks having structural arrangements or details which have suffered defects on similar tanks or on similar ships according to available information.
b) In tanks which have structures approved with reduced scantlings due to an approved corrosion control system.

3.4.8.3 For areas in tanks where coatings are found to be in a GOOD condition, the extent of Close-up Surveys according to Tables 3.4.8.1a and Table 3.4.8.1b may be specially considered by the Surveyor.

Table 3.4.8.1a : Minimum requirements to close-up surveys at special survey of oil tankers, ore/oil ships, ore/bulk/oil ships other than double hull oil tankers

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequently Age > 15**
A) One Web Frame Ring - in a ballast wing tank, if any, or a cargo wing tank used primarily for water ballast	**A) All Web Frame Rings** - in a ballast wing tank, if any, or a cargo wing tank, used primarily for water ballast	**A) All Web Frame Rings** - in all ballast tanks	As Special Survey No.3
B) One Deck Transverse - in a cargo oil tank	B) **One Deck Transverse** - in each of the remaining ballast tanks, if any	**A) All Web Frame Rings** - in a cargo wing tank	Additional transverses as deemed necessary by the Surveyor
D) **One Transverse Bulkhead** - in a ballast tank	B) **One Deck Transverse** - in a cargo wing tank	**A)**. A minimum of 30% of web frame rings [1)] in each remaining cargo wing tank	
D) **One Transverse Bulkhead** - in a cargo oil wing tank	B) **One Deck Transverse** - in two cargo centre tanks	**C) All Transverse Bulkheads** - in all cargo and ballast tanks	
D) **One Transverse Bulkhead** - in a cargo oil centre tank	C) **Both Transverse Bulkheads** - in a wing ballast tank, if any, or a cargo wing tank used primarily for water ballast	**E**) A minimum of 30% of deck and bottom transverses [1)] including adjacent structural members in each cargo centre tank	
	D) **One Transverse Bulkhead** - in each remaining ballast tank	**F)** As considered necessary by the Surveyor	
	D) **One Transverse Bulkhead** - in a cargo oil wing tank D) **One Transverse Bulkhead** - in two cargo centre tanks		

A) Complete transverse web frame ring including adjacent structural members

B) Deck transverse including adjacent deck structural members

C) Transverse bulkhead complete - including girder system and adjacent members

D) Transverse bulkhead lower part - including girder system and adjacent structural members

E) Deck and bottom transverse including adjacent structural members

F) Additional complete transverse web frame ring

Note : 1) The 30% is to be rounded up to the next whole integer.

<table>
<tr><th colspan="4">Table 3.4.8.1b : Minimum requirements for close-up survey at special survey of Double Hull Oil Tankers</th></tr>
<tr><th>Special Survey No. I
Age ≤ 5</th><th>Special Survey No. II
5 < Age ≤ 10</th><th>Special Survey No. III
10 < Age ≤ 15</th><th>Special Survey No. IV and subsequently
Age > 15</th></tr>
<tr><td>One web frame (1), in a complete ballast tank (see Note 1)</td><td>All web frames (1), in a complete ballast tank (see Note 1) The knuckle area and the upper part (5 metres approximately) of one web frame in each remaining ballast tank (6)</td><td>All web frames (1), in all ballast tanks</td><td rowspan="4">As for Special Survey for age from 10 to 15 years

Additional transverse areas as deemed necessary by IRS</td></tr>
<tr><td>One deck transverse, in a cargo oil tank (2)</td><td>One deck transverse, in two cargo oil tanks (2)</td><td>All web frames (7), including deck transverse and cross ties, if fitted, in a cargo oil tank

One web frame (7), including deck transverse and cross ties, if fitted, in each remaining cargo oil tank</td></tr>
<tr><td>One transverse bulkhead (4), in a complete ballast tank (see Note 1)</td><td>One transverse bulkhead (4), in each complete ballast tank (see Note 1)</td><td rowspan="2">All transverse bulkheads, in all cargo oil (3) and ballast (4) tanks</td></tr>
<tr><td>One transverse bulkhead (5) in a cargo oil centre tank

One transverse bulkhead (5), in a cargo oil wing tank (see Note 2)</td><td>One transverse bulkhead (5), in two cargo oil centre tanks

One transverse bulkheads (5), in a cargo oil wing tank (see Note 2)</td></tr>
</table>

(1), (2), (3), (4), (5), (6) and **(7)** are areas to be subjected to close-up surveys and thickness measurements (see Fig.3.4.8).

(1) : Web frame in a ballast tank means vertical web in side tank, hopper web in hopper tank, floor in double bottom tank and deck transverse in double deck tank (where fitted), including adjacent structural members. In fore and aft peak tanks web frame means a complete transverse web frame ring including adjacent structural members.

(2) : Deck transverse, including adjacent deck structural members (or external structure on deck in way of the tank, where applicable).

(3) : Transverse bulkhead complete in cargo tanks, including girder system, adjacent structural members (such as longitudinal bulkheads) and internal structure of lower and upper stools, where fitted.

(4) : Transverse bulkhead complete in ballast tanks, including girder system and adjacent structural members, such as longitudinal bulkheads, girders in double bottom tanks, inner bottom plating, hopper side, connecting brackets.

(5) : Transverse bulkhead lower part in cargo tank, including girder system, adjacent structural members (such as longitudinal bulkheads) and internal structure of lower stool, where fitted.

(6) : The knuckle area and the upper part (5 metres approximately), including adjacent structural members. Knuckle area is the area of the web frame around the connections of the slope hopper plating to the inner hull bulkhead and the inner bottom plating, upto 2 metres from the corners both on the bulkhead and the double bottom.

(7) : Web frame in a cargo oil tank means deck transverse, longitudinal bulkhead structural elements and cross ties, where fitted, including adjacent structural members.

Note 1 : Complete ballast tank : means double bottom tank plus double side tank plus double deck tank, as applicable, even if these tanks are separate.

Note 2 : Where no centre cargo tanks are fitted (as in the case of centre longitudinal bulkhead), transverse bulkheads in wing tanks are to be surveyed.

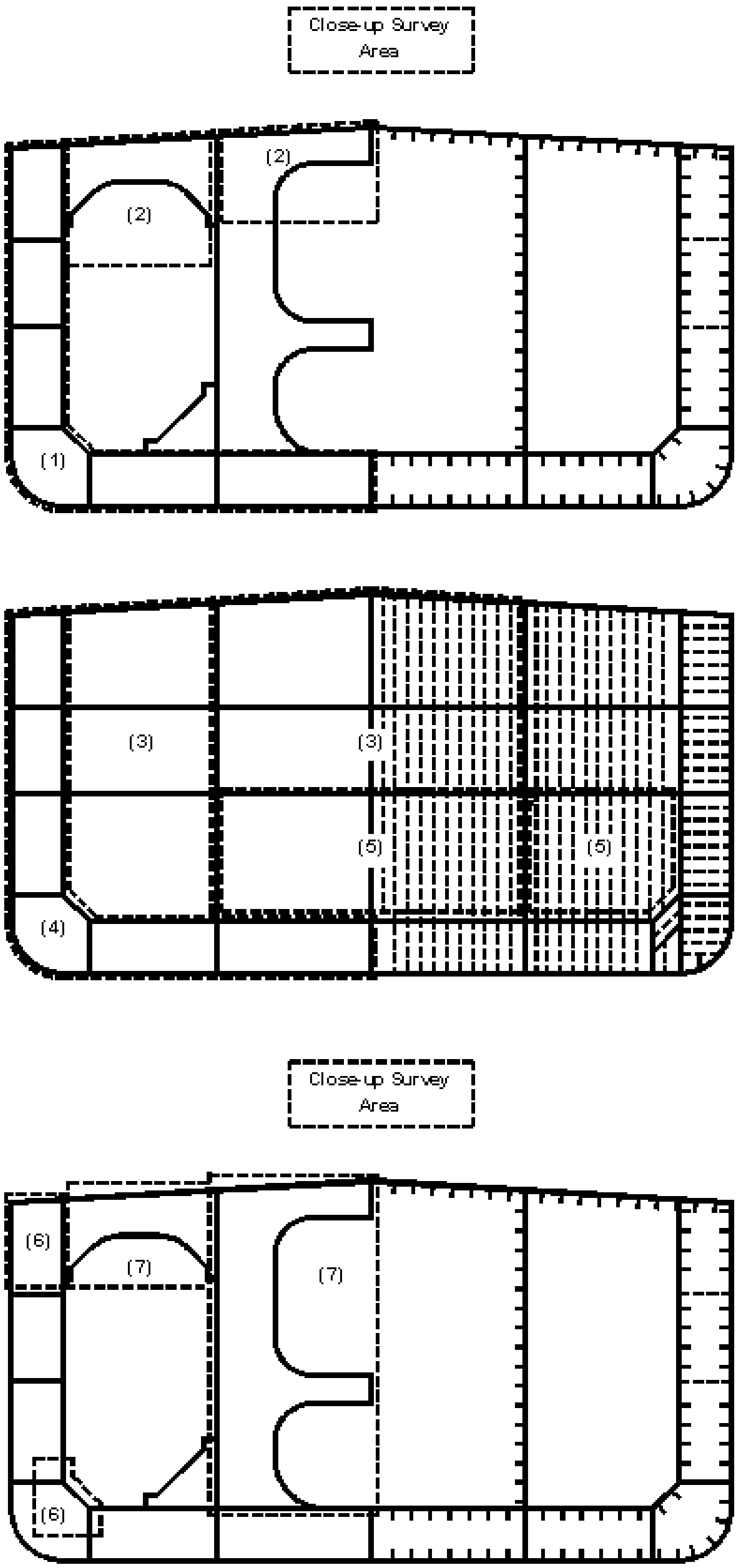

Fig.3.4.8 : Close-up survey requirements for double hull oil tankers areas (1) to (7)

3.4.9 Thickness measurement

3.4.9.1 The minimum requirements for thickness measurements at Special Survey are given in Table 3.4.9.1.

3.4.9.2 Provisions for extended measurements for areas with Substantial Corrosion in case of Oil Tankers, Ore/oil and Ore/Bulk/Oil Ships are given in Table 3.4.9.2a) and Table 3.4.9.2b).

For vessels built under IACS Common Structural Rules, the identified substantial corrosion areas are required to be examined and additional thickness measurements are to be carried out at annual and intermediate surveys.

The Surveyor may further extend the thickness measurements as deemed necessary.

3.4.9.3 In cases where two or three sections are to be measured in Oil Tankers, Ore/oil and Ore/Bulk/Oil Ships at least one is to include a Ballast Tank within 0.5L amidships.

Transverse sections are to be chosen where the largest reductions are suspected to occur or are revealed from deck plating measurements.

3.4.9.4 The thickness measurements are to be carried out by a qualified company certified by IRS.

3.4.9.5 In order to ensure necessary control during the process of thickness measurements these are normally to be carried out under the supervision of the Surveyor. The Surveyor has the right to re-check the measurements as deemed necessary to ensure acceptable accuracy.

3.4.9.6 In all cases the extent of thickness measurements is to be sufficient as to represent the actual average condition.

3.4.9.7 A thickness measurement report is to be prepared. The report is to give the location of measurements, the thickness measured as well as corresponding original thickness. Furthermore, the report is to give the date when the measurements were carried out, type of measuring equipment, names of personnel and their qualifications and has to be signed by the operator. The Surveyor is to review the report of the final thickness measurement after repairs have been carried out and countersign the cover page.

Table 3.4.9.1 : Table of minimum requirements to thickness measurements at special survey of oil tankers, ore/oil ships and ore/bulk/oil ships (including double hull oil tankers)

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequently** **Age > 15**
1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel
2) Within the cargo area: One section of deck plating for the full beam of the ship (in way of a ballast tank, if any, or a cargo tank used primarily for water ballast)	2) Within the cargo area: a) Each deck plate b) One Transverse section	2) Within the cargo area: a) Each deck plate b) Two Transverse sections c) All wind and water strakes	2) Within the cargo area: a) Each deck plate b) Three Transverse sections c) All wind and water strakes d) Each bottom plate
3) Measurements of structural members subject to close-up survey according to Table 3.4.8.1a and Table 3.4.8.1b, for general assessment and recording of corrosion pattern	3) Measurements of structural members subject to close-up survey according to Table 3.4.8.1a and Table 3.4.8.1b, for general assessment and recording of corrosion pattern	3) Measurements of structural members subject to close-up survey according to Table 3.4.8.1a and Table 3.4.8.1b, for general assessment and recording of corrosion pattern	3) Measurements of structural members subject to close-up survey according to Table 3.4.8.1a and Table 3.4.8.1b, for general assessment and recording of corrosion pattern

Table 3.4.9.1 (Contd.)			
Special Survey No. I Age ≤ 5	**Special Survey No. II 5 < Age ≤ 10**	**Special Survey No. III 10 < Age ≤ 15**	**Special Survey No. IV and subsequently Age > 15**
	4) Selected wind and water strakes outside the cargo area	4) Selected wind and water strakes outside the cargo area	4) All wind and water strakes outside the cargo area
		5) Internals in forepeak and after peak tanks	5) Internals in forepeak and after peak tanks
			6) All exposed main deck plating outside cargo area
			7) Representative exposed superstructure deck plating (poop, bridge, forecastle deck)
			8) All keel plates, additional bottom plates in way of machinery space, aft end of tanks and cofferdams outside cargo area
			9) a) Plating of sea chests. b) Shell plating in way of overboard discharges as considered necessary by the Surveyor.

Table 3.4.9.2a : Requirements for extent of thickness measurement on areas of substantial corrosion in oil tankers, ore/oil ships and ore/bulk/oil ships other than double hull oil tankers

Structural Member		Extent of Measurement	Pattern of Measurement
Bottom Structure			
1	Bottom plating	Minimum of 3 bays across tank including aft bay. Measurements around and under all bell mouths	5 point pattern between stiffeners over 1 metre in length
2	Bottom longitudinal	Minimum of 3 longitudinals in each bay where bottom plating measured	3 measurements in line across flange and 3 measurements on vertically web
3	Bottom girders and brackets	At fore and after transverse bulkhead bracket toes and in centre of tanks	Vertical line of single measurements on web plating with one measurement between each panel stiffener, or a minimum of three measurements. Two measurements across face flat. 5 point pattern on girder/bulkhead brackets
4	Bottom transverse webs	3 webs in bays where bottom plating measured, with measurements at both ends and middle	5 point pattern over 2 square metre area. Single measurements on face flat
5	Panel stiffening	Where provided	Single measurements

Table 3.4.9.2a (Contd.)

Structural Member		Extent of Measurement	Pattern of Measurement
Deck Structure			
1	Deck plating	Two bands across tank	Minimum of three measurements per plate per band
2	Deck longitudinals	Minimum of 3 longitudinals in each of two bays	3 measurements in line vertically on webs and 2 measurements on flange (if fitted)
3	Deck girders and brackets	At fore and after transverse bulkhead bracket toes and in centre of tanks	Vertical line of single measurements on web plating with one measurement between each panel stiffener, or a minimum of three measurements. Two measurements across face flat. 5 point pattern on girder/bulkhead brackets
4	Deck transverse webs	Minimum of two webs with measurements at middle and both ends of span	5 points pattern over 2 square metre area. Single measurements on face flat
5	Panel stiffening	Where provided	Single measurements
Shell and Longitudinal Bulkheads			
1	Deckheads and bottom strakes and strakes in way of stringer platforms	Plating between each pair of longitudinals in a minimum of 3 bays	Single measurement
2	All other strakes	Plating between every 3rd pair of longitudinals in same 3 bays	Single measurement
3	Longitudinals - deckhead and bottom strakes	Each longitudinal in same 3 bays	3 measurements across web and 1 measurement on flange
4	Longitudinals - all others	Every 3rd longitudinal in same 3 bays	3 measurements across web and 1 measurement on flange
5	Longitudinals - brackets	Minimum of 3 at top, middle and bottom of tank in same 3 bays	5 point pattern over area of bracket
6	Web frames and cross ties	3 webs with minimum of three locations on each web, including in way of cross tie connections	5 points pattern over about 2 sq. metre area, plus single measurements on web frame and across tie face flats
Transverse Bulkheads and Swash Bulkheads			
1	Deckhead and bottom strakes and strakes in way of stringer platforms	Plating between pair of stiffeners at three locations - approx. 1/4, 1/2 and 3/4 width of tank	5 points pattern between stiffeners over 1 metre length
2	All other strakes	Plating between pair of stiffeners at middle location	Single measurement
3	Strakes in corrugated bulkheads	Plating for each change of scantling at centre of panel and at flange or fabricated connection	5 point pattern over about 1 sq. metre of plating
4	Stiffeners	Minimum of three typical stiffeners	For web, 5 point pattern over span between bracket connections (2 measurements across web at each bracket connection and one at centre of span). For flange, single measurements at each bracket toe and at centre of span
5	Brackets	Minimum of three at top, middle and bottom of tank	5 point pattern over areas of bracket
6	Deep webs and girders	Measurements at toe of bracket and at centre of span	For web, 5 point pattern over about 1 sq. metre. 3 measurements across face flat
7	Stringer platforms	All stringers with measurements at both ends and middle	5 point pattern over 1 sq. metre of area plus single measurements near bracket toes and on face flats

Table 3.4.9.2b : Requirements for extent of thickness measurements at those areas of substantial corrosion - Special Survey of Double Hull Oil Tankers

Structural Member		Extent of Measurement	Pattern of Measurement
Bottom, Inner Bottom and Hopper Structure			
1	Bottom, inner bottom and hopper structure plating	Minimum of 3 bays across double bottom tank including aft bay.	5 point pattern for each panel between longitudinals and floors
		Measurements around and under all suction bell mouths	
2	Bottom, inner bottom and hopper structure longitudinals	Minimum of 3 longitudinals in each bay where bottom plating measured	3 measurements in line across flange and 3 measurements on vertical web
3	Bottom girders, including the watertight ones	At fore and aft watertight floors and in centre of tanks	Vertical line of single measurements on girder plating with one measurement between each panel stiffener, or a minimum of three measurements
4	Bottom floors, including the watertight ones	3 floors in bays where bottom plating measured, with measurements at both ends and middle	5 points pattern over 2 square metre area
5	Hopper structure web frame ring	3 floors in bays where bottom plating measured	5 point pattern over one square metre of plating. Single measurements on flange
6	Hopper structure transverse watertight bulkhead or swash bulkhead	Lower 1/3 of bulkhead	5 point pattern over two square metre of plating
		Upper 2/3 of bulkhead	5 point pattern over two square metre of plating
		Stiffeners (minimum of three)	For web, 5 point pattern over span (two measurements across web at each end and one at centre of span). For flange, single measurements at each end and centre of span
7	Panel stiffening	Where provided	Single measurements
Deck Structure			
1	Deck plating	Two transverse bands across tank	Minimum of three measurements per plate per band
2	Deck longitudinals	Every third longitudinal in each of two bands with a minimum of one longitudinal	3 measurements in line vertically on webs and 2 measurements on flange (if fitted)
3	Deck girders and brackets (usually in cargo tanks only)	At fwd and aft transverse bulkhead, bracket toes and in centre of tanks	Vertical line of single measurements on web plating with one measurement between each panel stiffener, or a minimum of three measurements. Two measurements across flange. 5 point pattern on girder/bulkhead brackets
4	Deck transverse webs	Minimum of two webs with measurements at both ends and middle of span	5 points pattern over one square metre area. Single measurements on face flat
5	Vertical web and transverse bulkhead in wing ballast tank (two metres from deck)	Minimum of two webs and both transverse bulkheads	5 point pattern over one square metre area
6	Panel stiffening	Where applicable	Single measurements

Table 3.4.9.2b (Contd.)			
Structural Member		**Extent of Measurement**	**Pattern of Measurement**
Structure in Wing Ballast Tanks			
1	Side shell and longitudinal bulkhead plating: - Upper strake and strakes in way of horizontal girders - All other strakes	- Plating between each pair of longitudinals in a minimum of 3 bays (along the tank) - Plating between every third pair of longitudinals in same 3 bays	- Single measurement - Single measurement
2	Side shell and longitudinal bulkhead longitudinals on: - Upper strake - All other strakes	- Each longitudinal in same 3 bays - Every third longitudinal in same 3 bays	- 3 measurements across web and 1 measurement one flange - 3 measurements across web and 1 measurement on flange
3	Longitudinals - brackets	Minimum of three at top, middle and bottom of tank in same three bays	5 point pattern over area of bracket
4	Vertical web and transverse bulkheads (excluding deckhead area): - Strakes in way of horizontal girders - Other strakes	- Minimum of two webs and both transverse bulkheads - Minimum of two webs and both transverse bulkheads	- 5 point pattern over approx. two square metre area - two measurements between each pair of vertical stiffeners
5	Horizontal girders	Plating on each girder in a minimum of three bays	2 measurements between each pair of longitudinal girder stiffeners
6	Panel stiffening	Where applicable	Single measurements
Longitudinal Bulkheads in Cargo Tanks			
1	Deckheads and bottom strakes and strakes in way of the horizontal stringer of transverse bulkheads	Plating between each pair of longitudinals in a minimum of 3 bays	Single measurement
2	All other strakes	Plating between every 3rd pair of longitudinals in same 3 bays	Single measurement
3	Longitudinals on deckhead and bottom strakes	Each longitudinal in same 3 bays	3 measurements across web and 1 measurement on flange
4	All other longitudinals	Every third longitudinal in same three bays	3 measurements across web and 1 measurement on flange
5	Longitudinals - brackets	Minimum of 3 at top, middle and bottom of tank in same 3 bays	5 point pattern over area of bracket
6	Web frames and cross ties	3 webs with minimum of three locations on each web, including in way of cross tie connections	5 points pattern over approximately 2 sq. metre area of webs, plus single measurements on flanges of web frame and cross ties
7	Lower end brackets (opposite side of web frame)	Minimum of three brackets	5 points pattern over approximately 2 sq. metre area of brackets, plus single measurements on bracket flanges
Transverse Watertight and Swash Bulkheads in Cargo Tanks			
1	Upper and lower stool, where fitted	- Transverse band within 25 mm of welded connection to inner bottom/deck plating - Transverse band within 25 mm of welded connection to shelf plate	5 point pattern between stiffeners over one metre length
2	Deckhead and bottom strakes and strakes in way of horizontal stringers	Plating between pair of stiffeners at three locations - approx. 1/4, 1/2 and 3/4 width of tank	5 points pattern between stiffeners over 1 metre length
3	All other strakes	Plating between pair of stiffeners at middle location	Single measurement
4	Strakes in corrugated bulkheads	Plating for each change of scantling at centre of panel and at flange of fabricated connection	5 point pattern over about 1 sq. metre of plating

Table 3.4.9.2b (Contd.)			
Structural Member		Extent of Measurement	Pattern of Measurement
5	Stiffeners	Minimum of three typical stiffeners	For web, 5 point pattern over span between bracket connections (2 measurements across web at each bracket connection and one at centre of span). For flange, single measurements at each bracket toe and at centre of span
6	Brackets	Minimum of three at top, middle and bottom of tank	5 point pattern over areas of bracket
7	Horizontal stringer	All stringers with measurements at both ends and middle	5 point pattern over 1 sq. metre of area plus single measurements near bracket toes and on flange

3.4.10 Reporting and evaluation of survey

3.4.10.1 The data and information on the structural condition of the vessel collected during the survey is to be evaluated for acceptability and continued structural integrity of the vessel.

3.4.10.2 In case of oil tankers of 130 [m] in length and upwards (as defined in ILLC), the ship's longitudinal strength is to be evaluated using the thickness of the structural members measured, renewed, reinforced, as appropriate, during the renewal survey of cargo ship safety construction certificate or the cargo ship safety certificate carried out after the ship reached 10 years of age in accordance with the criteria for longitudinal strength of the ship's hull girder

3.4.10.3 Where any structural renewal or reinforcement work is carried out as a result of the initial evaluation of the ship's longitudinal strength as required by 3.4.10.2, the final result of the evaluations is to be included as a part of the Executive hull summary.

3.4.10.4 An Executive Hull Summary of the survey and results is to be issued to the Owner and placed on board the vessel for reference at future surveys. The Executive Hull Summary is to be endorsed by IRS Head Office.

3.5 Special Surveys - Machinery

3.5.1 Requirements for examination of machinery and systems are given in Sec.8.

Section 4

Surveys - Chemical Tankers

4.1 Scope

4.1.1 This section gives the requirements for periodical surveys of vessels which have been assigned the class notation:

Chemical Tanker ESP

For vessels which also carry products covered by the IGC Code it may be necessary in accordance with Pt.5, Ch.4, Sec.1 to apply the survey requirements given in Sec.5 of this chapter.

4.2 Annual surveys

4.2.1 General

4.2.1.1 Annual Surveys are to be carried out within 3 months before or after the anniversary date each year. These should be held concurrently with statutory annual or other relevant statutory Surveys, where practicable.

4.2.1.2 At Annual Surveys, the Surveyor is to examine the hull and machinery, so far as necessary and practicable, in order to be satisfied as to their general condition.

4.2.1.3 Access to cargo tanks or other spaces within the cargo area, necessitating gas freeing will normally not be required unless necessary for checking items of equipment and installations for correct functioning.

4.2.1.4 It is to be confirmed that no new installation of material containing asbestos was carried out since last survey.

4.2.2 Hull and weather deck

4.2.2.1 The survey is to consist of an examination for the purpose of ensuring, as far as practicable, that the hull, equipment, closing appliances and related piping are maintained in satisfactory and efficient condition. Special attention is to be paid to the following:

a) Weather decks, ships side plating above waterline.

b) Openings on freeboard and superstructure decks; exposed casings; skylights and fiddley openings; deck houses; companionways and superstructure bulkheads; side scuttles and dead lights; flush deck scuttles; ash shoots and other openings.

c) Weld connection between air pipes and deck plating; air pipe heads on exposed decks (external examination); ventilators and closing devices.

d) Watertight bulkheads and their penetrations as far as practicable.

e) Scuppers and sanitary discharges as far as practicable together with valves and their controls.

f) Guard rails, bulwarks, freeing ports, gangways, walkways and life lines.

g) Examination of cargo tank openings including gaskets, covers, coamings and flame screens.

h) Examination of cargo tank pressure/vacuum valves, secondary means to prevent over or under pressure and devices to prevent passage of flame.

i) Examination of flame screens on vents to all bunker, tanks.

j) Examination of cargo, bunker and vent piping systems, including vent masts and headers.

k) Verification that wheelhouse doors and windows, side scuttles and windows in superstructure and deckhouse ends facing the cargo area are in good condition.

4.2.2.2 Examination of pump room and pipe tunnel, if fitted:

a) Examination of all pump room bulkheads for signs of chemical leakage or fractures and in particular, the sealing arrangements of all penetrations of pump room bulkheads.

b) Examination of the condition of all piping systems.

4.2.2.3 All watertight doors in watertight bulkheads, to be examined and tested (locally and remotely) as far as practicable.

4.2.2.4 Suspect areas identified at previous special or intermediate surveys are to be close-up surveyed. Thickness measurements are to be taken in the area of substantial corrosion identified at previous surveys.

4.2.2.5 Examination of Ballast Tanks is to be carried out when required as a consequence of the results of the Special Survey or Intermediate Survey. (See 4.4.5.1 and 4.3.3.3 respectively). When considered necessary by the Surveyor or where extensive corrosion is found, thickness measurement is to be carried out. When examination of ballast tanks reveals substantial corrosion, additional thickness measurements is to be carried out to the extent given in Table 4.4.9.2.

4.2.2.6 Anchoring and mooring equipment is to be examined as far as is practicable. A general examination of the emergency towing arrangements is to be carried out to ensure their ready availability.

For vessels with single point mooring arrangements where 'SPM' notation is assigned, the following are to be generally examined:

a) Components of the single point mooring system (bow chain stoppers, bow fairleads, pedestal roller fairleads, winches and capstans), to verify their satisfactory condition.

b) Hull structures supporting and adjacent to the components of the single point mooring system, to verify that there is no deformation or fracture.

4.2.2.7 Where applicable, Surveyor should satisfy himself regarding the freeboard marks on the ship's side.

4.2.2.8 The Surveyor is to confirm that, where required, an approved loading instrument together with its operation manual are available on board, See Pt.3, Ch.5. It is to be verified by the Surveyor that the loading instrument is checked for accuracy at regular intervals by the ship's staff by applying test loading conditions.

4.2.2.9 Accommodation ladders are to be examined at annual surveys. Satisfactory condition of the following items is to be checked, in particular :

a) steps;
b) platforms;
c) all support points such as pivots, rollers, etc.;
d) all suspension points such as lugs, brackets, etc.;
e) stanchions, rigid handrails, hand ropes and turntables;
f) davit structure, wire and sheaves, etc.

4.2.2.10 Gangways are to be examined at annual surveys. Satisfactory condition of the following items is to be checked, in particular :

a) treads;

b) side stringers, cross-members, decking, deck plates, etc.;

c) all support points such as wheel, roller, etc.;

d) stanchions, rigid handrails, hand ropes.

4.2.2.11 Winches of accommodation ladders and gangways are to be examined to verify the satisfactory condition of the following items:

a) brake mechanism including condition of brake pads and band brake, if fitted;

b) remote control system, and

c) power supply system for electric motor.

4.2.2.12 Davits and fittings on the ship’s deck associated with accommodation ladders and gangways are to be examined for satisfactory condition at annual surveys. Fittings or structures for means of access to deck such as handholds in a gateway or bulwark ladder and stanchions are also to be examined.

4.2.2.13 The maintenance and inspection records of accommodation ladders and gangways are to be verified. It is to be confirmed that supporting wires are being renewed at intervals not exceeding 5 years.

4.2.2.14 When examining internal spaces, as far as practicable, the permanent means of access where appropriate, are to be verified that they remain in good condition.

4.2.2.15 For vessels subject to IMO PSPC (See Pt.3, Ch.2, 3.6) it is to be confirmed that the maintenance, repair and partial re-coating of dedicated ballast tanks, as appropriate, are recorded in the coating technical file.

4.2.3 Machinery and systems

4.2.3.1 A general examination of the machinery, boilers, all pressurised systems (steam, pneumatic, hydraulic) and their associated fittings, propulsion system and auxiliary machinery to see whether they are being properly maintained and with particular attention to the fire and explosion hazards.

4.2.3.2 Confirmation that machinery, boilers and other pressure vessels, associated piping systems and fittings are so installed and protected as to reduce to a minimum any danger to persons on board, due regard being given to moving parts, hot surfaces and other hazards.

4.2.3.3 Confirmation that Periodical Surveys of boilers and other pressure vessels have been carried out as required by the Rules and the safety devices have been tested.

4.2.3.4 Confirmation that the normal operation of the propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative.

4.2.3.5 Confirmation that means are provided so that machinery can be brought into operation from the dead ship condition without external aid.

4.2.3.6 All main and auxiliary steering arrangements and their associated equipment and control systems are to be examined and tested. Where applicable, Surveyors are to verify that log entries have been made in accordance with statutory requirements.

4.2.3.7 Confirming, when appropriate, that requisite arrangements to regain steering capability in the event of the prescribed single failure are being maintained.

4.2.3.8 Steering chains are to be cleaned for ascertaining wear and tear and lengths of chain worn in mean diameter by more than 12 per cent of the original rule diameter are to be renewed.

4.2.3.9 All the means of communication between the navigating bridge and the machinery control positions, as well as the bridge and the main alternative steering position, if fitted, are to be tested. It is to be confirmed that means of indicating the angular position of the rudder are operating satisfactorily.

4.2.3.10 Confirmation that with ships having emergency steering positions there are means of relaying heading information and, when appropriate, supplying visual compass readings to the emergency steering positions.

4.2.3.11 Confirmation that various alarms required for hydraulic power operated, electric and electro-hydraulic steering gears are, operating satisfactorily and that the recharging arrangements for hydraulic power operated steering gears are being maintained.

4.2.3.12 Examining the means for the operation of the main and auxiliary machinery essential for propulsion and the safety of the ship, including when applicable, the means of remotely controlling the propulsion machinery from the navigating bridge and the arrangements to operate the main and other machinery from a machinery control room.

4.2.3.13 Confirmation that the engine room telegraph, the second means of communication between the navigation bridge and the machinery space and the means of communication with any other positions from which the engines are controlled are operating satisfactorily.

4.2.3.14 Confirmation that the engineer's alarm is clearly audible in the engineer's acco-mmodation.

4.2.3.15 The bilge pumping systems and bilge wells including operation of each bilge pump, extended spindles and level alarms, where fitted, are to be examined as far as is practicable. It is also to be confirmed that bilge pumping system for each watertight compartment is satisfactory.

It is also to be confirmed that drainage from enclosed cargo spaces situated on freeboard deck is satisfactory.

4.2.3.16 Examining visually the condition of any expansion joints in sea water system.

4.2.3.17 General examination visually and in operation, as feasible, of the main electrical machinery, the emergency sources of electrical power, the switch gear, other electrical equipment including the lighting system is to be carried out.

4.2.3.18 Confirmation as far as practicable, the operation of the emergency source(s) of electrical power, including their starting arrangement, the systems supplied, and when appropriate, their automatic operation.

4.2.3.19 Examining in general, that the precautions provided against shock, fire and other hazards of electrical origin are being maintained.

4.2.3.20 General Examination of automation equipment is to be carried out. Satisfactory operation of safety devices, bilge level detection and alarm systems and control systems is to be verified.

4.2.3.21 Examination so far as is possible of cargo, bilge, ballast and stripping pumps for excessive gland seal leakage, verification of proper operation of electrical and mechanical remote operating and shutdown devices and remote operation of pump room bilge system, and checking that pump foundations are intact.

4.2.3.22 Verification that installed pressure gauges on cargo discharge lines including those fitted outside the cargo pump room and level indicating systems are operational.

4.2.3.23 Verification that pumps, valves and pipelines are identified and distinctively marked.

4.2.3.24 Confirmation that machinery space ventilation systems are in good working condition.

4.2.4 Fire protection, detection and extinction

4.2.4.1 The arrangements for fire protection, detection and extinction are to be examined and are to include confirmation that no changes have been made in the structural fire protection. Following are to be examined / verified:

a) verification that fire control plans are properly posted;

b) examination as far as possible and testing as feasible of the fire and/or smoke detection system(s);

c) examination of the fire main system and verification that each fire pump including the emergency fire pump can be operated separately so that the two required powerful jets of water can be produced simultaneously from different hydrants;

d) verification that fire hoses, nozzles, applicators and spanners are in good working condition and situated at their respective locations;

e) examination of fixed fire fighting system controls, piping, instructions and marking, checking for evidence of proper maintenance and servicing including date of last systems tests;

f) verification that all semi-portable and portable fire extinguishers are in their stowed positions, checking for evidence of proper maintenance and servicing, conducting random check for evidence of discharged containers;

g) verification, as far as practicable, that the remote controls for stopping fans and machinery and shutting off fuel supplies in machinery spaces are in working order;

h) examination of the closing arrangements of ventilators, funnel annular spaces, skylights, doorways and tunnel, where applicable;

i) confirmation that the fire fighters' outfits and emergency escape breathing devices (EEBDs) are complete and in good condition and that the cylinders, including the spare cylinders, of any required self-contained breathing apparatus are suitably charged;

j) examination of any manual and automatic fire doors and proving their operations;

k) Verification that the pump room ventilation system is operational, ducting intact, dampers operational and screens are clean;

l) External examination of piping and cut-out valves of cargo tank and cargo pump room fixed fire fighting system;

m) Verification that all electrical equipment in dangerous zones is in good condition and has been properly maintained so far as is practicable;

n) Checking the deck foam system, including the supplies of foam concentrate and testing that minimum number of jets of water at the required pressure in the fire main is obtained when the system is in operation;

o) Examining the fixed fire fighting system for the cargo pump room and the deck foam system for the cargo area and confirming that their means of operation are clearly marked;

p) Confirming that potential sources of ignition in or near the cargo pump room are eliminated, such as loose gear, combustible materials etc., that there are no signs of undue leakage and that access ladders are in satisfactory condition;

q) Confirming that the condition of portable fire fighting equipment for the cargoes to be carried in the cargo area is satisfactory;

r) examination of the fire-extinguishing systems for spaces containing paint and/or flammable liquids and deep fat cooking equipment in accommodation and service spaces;

s) examination of the fire safety requirements of any helicopter facilities;

t) Confirming, as far as practicable, that the intrinsically safe systems and circuits used for measurement, monitoring, control and communication purposes in all hazardous locations are being properly maintained.

u) Confirming that the system for continuous monitoring of the concentration of flammable vapours is satisfactory. (Refer Pt.5, Ch.3, Cl. 11.1.4).

v) Confirming that sampling points or detector heads are located in suitable positions in order that potentially dangerous leakages are readily detected. (Refer Pt.5, Ch.3, Cl. 11.1.4).

Surveys carried out by the National Authority of the country in which the ship is registered would normally be accepted as meeting these requirements, at the discretion of the Surveyor.

4.2.4.2 For tankers fitted with inert gas system, examination of the inert gas system as detailed in Section 12, Para 12.2.1 is to be carried out.

4.2.4.3 Confirmation that the means of escape from accommodation, machinery spaces and other spaces are satisfactory.

4.2.4.4 Examination of the arrangements for gaseous fuel for domestic purposes.

4.2.5 Other safety arrangements related to cargo

4.2.5.1 The following are to be dealt with where applicable:

a) Examination of gauging devices, high level alarms and valves associated with overflow control.

b) Verification that any devices provided for measuring the temperature of the cargo and any associated alarms are satisfactory.

c) Examination of the cargo heating/cooling system sampling arrangements where fitted.

d) Verification that removable pipe lengths or other approved equipment necessary for cargo separation are available, and satisfactory.

e) Verification that the ventilation system including portable equipment, if any, of all spaces in the cargo area is operational.

f) Verification that arrangements are made for sufficient inert/padding/drying gas to be carried to compensate for normal losses and that means are provided for monitoring of ullage spaces.

g) Verification that arrangements are made for sufficient medium to be carried where drying agents are used on air inlets to cargo tanks.

h) Examining the cargo transfer arrangements and confirming that any hoses are suitable for their intended purpose.

i) Verification that any special arrangements made for bow or stern loading and unloading are in good condition and testing the means of communication and remote shutdown of the cargo pump.

j) Verification that, if applicable, the provisions made for chemicals which have special requirements listed in relevant Ch.3 of Pt.5 of the Rules are in order.

4.2.6 Personnel protection

a) Verification that cargo pump room rescue arrangements are in order.

b) Verification that suitable protective clothing is available for crew engaged in loading and discharging operations and that suitable storage is maintained.

c) Verification that the requisite safety equipment and associated breathing apparatus with requisite air supplies and emergency escape respiratory and eye protection, if required, are in good condition and are properly stowed.

d) Verification that medical first aid equipment including stretchers and oxygen resuscitation is in good condition and that satisfactory arrangements are made for antidotes for cargoes actually carried to be on board.

e) Verification that decontamination arrange-ments are operational.

f) Verification that the requisite gas detection instruments are on board and that satisfactory arrangements are made for the supply of any required vapour detection tubes.

g) Verification that the cargo sample stowage arrangements are in good condition.

4.3 Intermediate Surveys

4.3.1 General

4.3.1.1 Intermediate surveys are to be carried out at or between the second or third Annual Survey. However, only those items which are additional to the requirements of annual survey may be examined between the second or third annual survey.

Concurrent crediting to both Intermediate survey and Special survey for surveys and thickness measurements of spaces is not acceptable.

4.3.1.2 The following requirements are applicable for vessels over five years of age. For vessels below 5 years of age additional examination over and above the requirements of Annual survey may be required at the discretion of the Surveyors.

4.3.1.3 For vessels over 10 years of age a specific survey program is to be worked out by the owner in cooperation with the Surveyors considering the requirements of the previous special survey, executive hull summary of that survey, later relevant survey records and taking account of any amendments to the survey requirements after the last special survey. The survey program is to be submitted in written format for approval and kept on board until the intermediate survey has been completed. (See 4.4.2 for guidance on preparation of survey program).

4.3.1.4 Prior to the commencement of any part of the intermediate survey, a survey planning meeting is to be held between the attending Surveyor(s), the owner's representative in attendance and where involved, the thickness measurement company representative and the master of ship or an appropriately qualified representative appointed by the master or Company for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

4.3.2 Examination tanks and spaces

4.3.2.1 The survey of integral cargo tanks and ballast tanks depending on the age of the vessel is to be carried out as specified in 4.3.3 to 4.3.5.

4.3.3 Chemical tankers between 5 and 10 years of age

4.3.3.1 The following are to be carried out:

For ballast tanks, an Overall Survey of Representative Tanks selected by the Surveyor is to be carried out. If such inspections reveal no visible structural defects, the examination may be limited to a verification that the hard Protective Coating remains in GOOD condition.

4.3.3.2 In addition to the requirements above, suspect areas identified at previous surveys are to be examined.

4.3.3.3 A ballast tank is to be examined at subsequent annual intervals where:

a) a hard protective coating has not been applied from the time of construction, or
b) a soft or semi-hard coating has been applied, or
c) substantial corrosion is found within the tank, or
d) the hard protective coating is found to be in less than GOOD condition and the hard protective coating is not repaired to the satisfaction of the Surveyor.

4.3.4 Chemical tankers between 10 and 15 years of age

4.3.4.1 The requirements of the intermediate survey are to be to the same extent as the previous special survey as required in 4.4 for hull structure and piping systems in way of cargo holds, cofferdams, pipe tunnels, void spaces within the cargo area and all ballast tanks. However, testing of cargo and ballast tanks and survey of automatic air pipe heads specified in 4.4.6.2 are not required unless deemed necessary by the attending surveyor. Thickness measurement is to be carried out for items 1) to 4) of Table 4.4.9.1.

4.3.4.2 The intermediate survey may be commenced at the second annual survey and be progressed during the succeeding year with a view to completion at the third annual survey in lieu of the application of 4.4.1.4.

4.3.4.3 An in-water survey complying with the requirements of Sec.7.2 may be accepted in lieu of the requirements of 4.4.1.10.

4.3.5 Chemical tankers exceeding 15 years of age the following is to apply:

4.3.5.1 The requirements of the intermediate survey are to be to the same extent as the previous special survey as required in 4.4 for hull structure and piping systems in way of cargo holds, cofferdams, pipe tunnels, void spaces within the cargo area and all ballast tanks. However, testing of cargo and ballast tanks is not required unless deemed necessary by the attending surveyor. Thickness measurement is to be carried out for items 1) to 4) of Table 4.4.9.1.

4.3.5.2 For the application of 4.3.5.1 the intermediate survey may be commenced at the second annual survey and be progressed during the succeeding year with a view to completion at the third annual survey in lieu of the application of 4.4.1.4.

4.3.5.3 A survey in dry dock is to be part of the intermediate survey. Any remaining work in respect of the overall and close-up surveys and thickness measurements and repairs applicable to the lower portions of cargo tanks and water ballast tanks (i.e. parts below light ballast waterline) are to be completed in the dry-dock.

4.3.6 Safety arrangements related to cargo

4.3.6.1 The following are to be dealt with as applicable:

a) Examination of vent line drainage arrangements.

b) Verification that the cargo heating/cooling system is in good condition.

c) Verification that the ship's cargo hoses are approved and in good condition.

d) Verification that where applicable, pipelines and independent cargo tanks are electrically bonded to the hull.

e) An examination of cargo, cargo washing, bunker, ballast, steam and vent piping on the weather decks, as well as vent masts and headers. If upon examination there is any doubt as to the condition of the piping, the pipe may require to be pressure tested, gauged or both.

f) A General Examination of the electrical equipment and cables in dangerous zones such as cargo pump-rooms, and areas adjacent to cargo tanks for defective certified safe type equipment, improperly installed wiring, non-approved lighting and fixtures and dead end wiring. Testing insulation resistance of the circuits except in cases where a proper record of the testing is maintained, consideration is to be given to accepting recent readings by the crew. If any of the readings are marginal or if the condition of the cables, fixtures or equipments appears defective in any way, verification measurements may be required. These measurements are not to be attempted until the ship is in a gas free condition and are to be carried out within an acceptable time period.

g) Confirmation that spares are provided for cargo area mechanical ventilation fans.

h) Examining the equipment for personal protection.

i) Examining externally and confirming that the pumping and piping systems, including a stripping system if fitted and associated equipment remain as approved.

j) Examining externally the tank washing piping and confirming that the type, capacity, number and arrangement of the tank washing machines are as approved.

k) Examining externally the wash water heating system.

l) Examining externally, as far as practicable the underwater discharge arrangement.

m) Confirming that the means of controlling the rate of discharge of the residue is as approved.

n) Confirming that flow rate indicating device is operable.

o) Confirming that the ventilation equipment for residue removal is as approved and satisfactory.

p) Examining externally, as far as is accessible, the heating system required for solidifying and high viscosity substances.

q) Confirming that any cargo tank high level alarms are operable.

r) Verifying from the Cargo Record Book that the pumping and stripping arrangements have been emptying the tanks efficiently and all are in working order.

s) Confirming, if possible, that the discharge outlets are in good condition.

t) Confirming the satisfactory operation of the recording device, as fitted and verifying by an actual flow test that it has an accuracy of $\pm$ 15% or better.

Surveys carried out by the National Authority of the country in which the ship is registered may be accepted at the discretion of the Surveyor as meeting these additional requirements.

4.4 Special Surveys - Hull

4.4.1 General

4.4.1.1 All ships classed with IRS are to undergo Special Surveys at 5 yearly intervals. The first Special Survey is to be completed within 5 years from the date of the initial classification survey and thereafter 5 years from the assigned date of the previous Special Survey. However, an extension of class of 3 months maximum beyond the 5th year may be granted in exceptional circumstances in accordance with 1.11. In such cases, the next period of class will start from the expiry date of the Special Survey before extension was granted.

4.4.1.2 The interval between the Special Surveys may be reduced at the request of the parties concerned or by IRS if considered appropriate.

4.4.1.3 For surveys completed within 3 months before the expiry date of the Special Survey, the next period of class will start from the expiry date of the Special Survey. For surveys completed more than 3 months before the expiry date of the Special Survey, the period of class will start from the survey completion date. In cases where the vessel has been laid up or has been out of service for a considerable period because of a major repair or modification and the owner elects to only carry out the overdue surveys, the next period of class will start from the expiry date of the special survey. If the owner elects to carry out the next due special survey, the period of class will start from the survey completion date. Any requirement of the Flag Administration in this regard is also to be complied with.

4.4.1.4 The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date. When the special survey is commenced prior to the fourth annual survey, the entire survey is to be completed within 15 months if such work is to be credited to the special survey and in this case the next period of class will start from the survey completion date.

Concurrent crediting to both Intermediate survey and Special survey for surveys and thickness measurements of spaces is not acceptable.

4.4.1.5 As part of the preparation for Special Survey, the proposed Survey Programme (See 4.4.2) including the schedule for thickness measurements (See 4.4.9) are to be submitted at least 3 months in advance of the intended commencement of the Special Survey.

4.4.1.6 Record of Special Survey will not be assigned until the Machinery Survey has been completed or postponed in agreement with IRS.

4.4.1.7 Ships which have satisfactorily passed a Special Survey will have a record entered in the Supplement to the Register Book indicating the assigned date of Special Survey. In addition a notation "ESP" will be entered for chemical tankers.

4.4.1.8 The special survey is to include, in addition to the requirements of the Annual Survey, examination, tests and checks of sufficient extent to ensure that the hull, equipment and related piping are in satisfactory condition and that the ship is fit for its intended purpose for the next five (5) year class period, subject to proper maintenance and operation and the periodical surveys being carried out at the due dates.

4.4.1.9 The special survey requirements to be applied in respect of independent cargo tanks are given in 4.4.11.

4.4.1.10 A Docking Survey in accordance with the requirements of Sec.7 is to be carried out as part of the Special Survey. Any remaining work in respect of the overall and close-up surveys and thickness measurements and repairs applicable to the lower portions of cargo tanks and water ballast tanks (i.e. parts below light ballast water line) are to be completed in the dry-dock.

4.4.2 Planning and preparation for survey

4.4.2.1 A specific Survey Programme is to be worked out in advance of the Survey by the Owner in cooperation with the Surveyors and submitted to IRS for approval. The Survey Programme shall be in a written format prior to the development of survey programme, the survey planning questionnaire in prescribed format is to be completed by the owner and forwarded to IRS. The survey program is to be worked out taking into account any amendments to the survey requirements after the last special survey.

4.4.2.2 In developing the Survey Programme, the following documentation is to be collected and consulted with a view to selecting tanks, areas and structural areas for examination :

a) Survey status and basic ship information

b) Documentation on board as per 4.4.3

c) Main structural plans (scantling drawings), including information regarding use of high strength steels, clad steel and stainless steel

d) Executive hull summary

e) Relevant previous damage and repair history

f) Relevant previous survey and inspection reports of IRS and the Owners

g) Information regarding the use of the ship's holds and tanks, typical cargoes and other relevant data

h) Details of the inert gas plant and tank cleaning procedures

i) Information and other relevant data regarding conversion or modification of the ship's cargo and ballast tanks since the time of construction

j) Description and history of the coating and corrosion protection system (previous class notations), if any

k) Inspections by the Owner's personnel during the last 3 years with reference to structural deterioration in general, leakages in tank boundaries and piping and condition of the coating and corrosion protection system, if any

l) Information regarding the relevant maintenance level during operation including port state control reports of inspection containing hull related deficiencies. Safety Management System non-conformities relating to hull maintenance, including the associated corrective action(s); and

m) Any other information that will help identify suspect areas and critical structural areas.

4.4.2.3 The Survey Programme submitted for approval is to account for and comply, as a minimum, with the requirements of close-up survey, thickness measurement, tank testing and pipe testing respectively, and to include relevant information including at least :

a) Basic ship information and particulars

b) Main structural plans (scantling drawings), including information regarding use of high strength steels, clad steel and stainless steel

c) Plan of tanks

d) List of tanks with information on use, corrosion prevention and condition of coating

e) Conditions for survey (e.g. information like tank cleaning, gas freeing, ventilation, lighting, etc.)

f) Provisions and methods of access to structures

g) Equipment for survey

h) Nomination of tanks and areas for close-up survey (As per Table 4.4.8.1a) and Table 4.4.8.1b))

i) Nomination of sections for thickness measurement (As per Table 4.4.9.1)

j) Nomination of tanks for testing and the pipes that are to undergo pipe testing as per 4.4.10

k) Identification of the thickness measurement company

l) Damage experience related to the ship in operation.

m) Critical structural areas and suspect areas, where relevant.

4.4.2.4 IRS will advise the Owner of the maximum acceptable structural corrosion diminution levels applicable to the vessel.

4.4.2.5 The ship is to be prepared for overall survey in accordance with the requirements of Table 4.4.2.5. The preparation is to be of sufficient extent to facilitate an examination to ascertain any excessive corrosion, deformation, fractures, damages and other structural deterioration.

4.4.2.6 Proper preparation and close co-operation between the attending surveyor(s) and the owner's representatives onboard prior to and during the survey are an essential part in the safe and efficient conduct of the survey. During the survey on board safety meetings are to be held regularly.

4.4.2.7 Prior to the commencement of any part of the Special and Intermediate Survey a survey planning meeting is to be held between the attending Surveyor(s), the Owner's representative in attendance and the thickness measurement company representative, where involved, and the master of the ship or an appropriately qualified representative appointed by the master or Company for the purpose of ascertaining that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

4.4.2.8 The following is an indicative list of items that are to be addressed in the meeting:

a) Schedule of the vessel (i.e. the voyage, docking and undocking manoeuvres, periods alongside, cargo and ballast operations etc.);

b) Provisions and arrangements for thickness measurements (i.e. access, cleaning / de-scaling, illumination, ventilation, personal safety);

c) Extent of the thickness measurements;

d) Acceptance criteria (refer to the list of minimum thicknesses);

e) Extent of close-up survey and thickness measurement considering the coating condition and suspect areas / areas of substantial corrosion;

Table 4.4.2.5 : Survey preparation

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequently** **Age > 15**
1) All tanks, peaks, bilges and drain wells, engine and boiler spaces and other spaces are to be cleared out and cleaned as necessary for examination. Floor plates in engine and boiler spaces are to be lifted as may be necessary for examination of the structure underneath. Where necessary ceiling, lining, casings and loose insulation are to be removed as required by the Surveyor for examination of the structure. Compositions on the plating are to be examined and sounded, but need not be disturbed if found satisfactorily adhering to the plating 2) The steelwork is to be exposed and cleaned as may be required for its proper examination by the Surveyor and close attention is to be paid to the parts of the structure which are particularly liable to excessive corrosion or to deterioration due to other causes. 3) All tanks are to be cleaned as necessary to permit examination. 4) Casings or covers of air, sounding, steam and other pipes, spar ceiling and lining in way of the side scuttles are to be removed, as required by the Surveyor.	1) Requirements of Special Survey I to be complied with 2) The chain locker is to be cleaned internally. The chain cables are to be ranged for inspection. The anchors are to be cleaned and placed in an accessible position for inspection.	1) Requirements of Special Survey II to be complied with 2) Portions of wood sheathing, or other covering, on steel decks are to be removed, as considered necessary by the Surveyor, in order to ascertain the condition of the plating.	1) Requirements of Special survey III to be complied with

f) Execution of thickness measurements;

g) Taking representative readings in general and where uneven corrosion / pitting is found;

h) Mapping of areas of substantial corrosion; and

i) Communication between attending surveyor(s) the thickness measurement, company operator(s) and owners representative(s) concerning findings.

4.4.3 Documentation on board

4.4.3.1 The Owners are to obtain supply and maintain on board documentation as specified in 4.4.3.3, which is to be readily available for the Surveyor.

4.4.3.2 The documentation is to be kept on board for the life time of the ship.

4.4.3.3 A Survey Report File is to be a part of the documentation on board consisting of

- Reports of structural surveys
- Executive Hull Summary
- Thickness measurement reports.

4.4.3.4 The Survey Report File is to be available also in the Owners management offices and with IRS.

4.4.3.5 The following additional supporting documentation is to be available on board:

- Main structural plans of cargo holds, cargo and ballast tanks
- Previous repair history
- Cargo and ballast history
- Extent of use of inert gas plant and tank cleaning procedures
- Inspection by ship's personnel with reference to

    - structural deterioration in general
    - leakages in bulkheads and piping
    - condition of coating or corrosion prevention systems, if any

- Any other information that will help identify critical structural areas or Suspect Areas requiring inspection

- Survey Programme as required by 4.4.2 until such time as the Special Survey has been completed.

4.4.3.6 Prior to survey, the Surveyor is to examine the completeness of the documentation on board, and its contents as a basis for the survey.

4.4.4 Surveys at sea or at anchorage

4.4.4.1 See Sec.1.8.

4.4.5 Space protection

4.4.5.1 Where provided, the condition of the corrosion prevention system of cargo tanks is to be examined.

A ballast tank is to be examined at subsequent annual intervals where:

a) a hard protective coating has not been applied from the time of construction, or
b) a soft or semi-hard coating has been applied, or
c) substantial corrosion is found within the tank, or
d) the hard protective coating is found to be in less than GOOD condition and the hard protective coating is not repaired to the satisfaction of the Surveyor.

4.4.5.2 Where the hard protective coating in cargo tanks is found to be in GOOD condition, the extent of close-up surveys and thickness measurements may be specially considered.

4.4.6 Survey and examination

4.4.6.1 All spaces within the hull and superstructure are to be examined.

4.4.6.2 All tanks other than cargo and ballast tanks are to be examined internally in accordance with the requirements of Table 4.4.6.2.

4.4.6.3 An overall survey of all cargo tanks, ballast tanks including double bottom tanks, pipe tunnels, cofferdams and void spaces bounding cargo tanks, decks and outer hull is to be carried out. This examination is to be supplemented by thickness measurement and testing as required by 4.4.9 and 4.4.7 to ensure that the structural integrity remains effective. The aim of the examination is to discover Substantial Corrosion, significant deformation, fractures, damages or other structural deterioration and if deemed necessary by the Surveyor, a suitable non-destructive examination may be required.

Table 4.4.6.2 : Requirements for internal examination of tanks

Tank	Special Survey No. I Age ≤ 5	Special Survey No. II 5 < Age ≤ 10	Special Survey No. III 10 < Age ≤ 15	Special Survey No. IV and subsequent Age > 15
Fuel oil bunker tanks - Engine room - Other area	 None None	 None One	 One Two	 One Half the number of tanks, minimum 2
Lub.oil	None	None	None	One
Fresh water	None	One	All	All

Notes:

1) These requirements apply to tanks of integral (structural) type.
2) If a selection of tanks is accepted to be examined, then different tanks are to be examined at each special survey, on a rotational basis.
3) Peak tanks (all uses) are subject to internal examination at each special survey.
4) At special survey No.III and subsequent special surveys, one deep tank for fuel oil is to be included, if fitted.

4.4.6.4 Cargo piping on deck and cargo and ballast piping systems within the above tanks and spaces are to be examined and operationally tested to working pressure to attending Surveyor's satisfaction to ensure that tightness and condition remain satisfactory. Special attention is to be given to ballast piping in cargo tanks and cargo piping in Ballast Tanks and void spaces and Surveyors are to be advised on all occasions when this piping, including valves and fittings are open during repair periods and can be examined internally.

4.4.6.5 Where ballast tanks have been converted to void spaces, the survey extent is to be based upon ballast tank requirements.

4.4.6.6 All watertight bulkheads and watertight doors are to be examined. All decks, casings and superstructures are to be examined. Attention is to be given to the corners of openings and other discontinuities in way of the strength decks and top sides.

4.4.6.7 The masts, standing rigging and anchors are to be examined.

The Surveyor should satisfy himself that there are sufficient mooring ropes on board and also that a tow line is provided when this is a Rule requirement.

4.4.6.8 The steering gear, and its connections and control systems (main and alternative) are to be examined. The auxiliary steering gear with its various parts are to be examined in working condition.

4.4.6.9 The hand pumps and suctions, air and sounding pipes are to be examined. The Surveyors are to ensure that striking plates are fitted under the sounding pipes whilst examining the tanks internally.

Automatic air pipe heads are to be internally examined at special surveys as indicated in Table 4.4.6.9. For designs where the inner parts cannot be properly inspected from outside, the head is to be removed from the air pipe. Particular attention is to be paid to the condition of the zinc coating in heads constructed from galvanised steel.

4.4.6.10 The Surveyor should satisfy himself regarding the efficient condition of the following :

- Means of escape from machinery spaces, crew and passenger spaces and spaces in which crew are normally employed;
- Means of communication between bridge and engine room and between bridge and alternative steering position;
- Helm indicator;
- Protection to the aft steering wheel and the gear.

Table 4.4.6.9 : Requirements for internal examination of automatic air pipe heads			
Location	**Special survey No.I Age ≤ 5**	**Special survey No.II 5 < Age ≤ 10**	**Special survey No.III and subsequent Age > 10**
forward 0.25L	Two air pipe heads[1,2] one port and one starboard on exposed decks	All air pipe heads on exposed decks	All air pipe heads[3] on exposed decks
aft of 0.25L from the forward perpendicular	Two air pipe heads[1,2] one port and one starboard on exposed decks	At least 20% of air pipe heads[1,2] on exposed decks	

Notes:

1. Preferably air pipes serving ballast tanks.
2. The selection of air pipe heads is to be made by the attending Surveyor. According to the results of the inspection, the Surveyor may require additional air pipe heads to be examined.
3. When there is substantiated evidence of replacement within the previous five years, individual air pipe heads may not be examined.

4.4.6.11 The chain cables are to be ranged and the anchors and the chain cables are to be examined. At special survey no. II and subsequent special surveys, the chain cables are to be gauged. Any length of chain cable which is found to have reduced in mean diameter at its most worn part by more than 12 per cent of its original rule diameter is to be renewed.

4.4.6.12 The windlass is to be examined.

4.4.6.13 The chain locker, hold fasts, hawse pipes and chain stoppers are to be examined and pumping arrangements of the chain locker tested.

4.4.6.14 A thorough examination of aft and forward emergency towing arrangements is to be carried out to ensure its ready availability and satisfactory condition.

- examination of pick-up gear, towing pennant and chafing gear for possible deterioration;

- examination of strong points, fairleads, pedestal roller and their attachment to hull structure.

The survey is to confirm that one of the towing arrangements (aft or forward) are pre-rigged.

4.4.6.15 For vessels with single point mooring arrangements where 'SPM' notation is assigned, the following is to be carried out:

a) A thorough examination of the components of the single point mooring system (bow chain stoppers, bow fairleads, pedestal roller fairleads, winches and capstans) to verify their satisfactory condition.

b) A close-up examination of the hull structures supporting and adjacent to the components of the single point mooring system to verify that there is no deformation or fracture. Thickness determination and non-destructive tests are to be carried out if required by the Surveyor.

4.4.6.16 Engine room structure is to be examined. Particular attention being given to tank tops, shell plating in way of tank tops, brackets connecting side shell frames and tank tops and engine room bulkheads in way of tank tops and bilge wells. Where excessive areas of wastage are found, thickness measurements are to be carried out and renewals of repairs made when wastage exceeds allowable limits.

4.4.6.17 The attachment to the structure and condition of anodes in tanks is to be examined.

4.4.6.18 Where fitted, the strums of the cargo suction pipes are to be removed or lifted to facilitate examination of the shell plating and bulkheads in the vicinity, unless other means for visual inspection of these parts are provided.

4.4.6.19 The loading instrument is to be checked for accuracy by applying test load conditions in presence of the Surveyor.

4.4.6.20 Examination of accommodation ladders, gangways and their winches are to be carried out as required for annual surveys. In addition, the accommodation ladders and gangways are to be operationally, tested with the specified maximum operation load.

The tests are to be carried out with the load applied as uniformly as possible along the length of the accommodation ladder or gangway, at an angle of inclination corresponding to the maximum bending moment on the accommodation ladder or gangway.

Accommodation ladder winch is to be operationally tested at special surveys. The brake system of the winch is to be tested for holding the maximum operational load on the ladder.

For existing installations on board ships constructed prior to 01 Jan 2010 where the maximum operational load is not known, load nominated by the shipowner or operator may be considered as the test load.

4.4.7 Extent of tank testing

4.4.7.1 The minimum requirements for tank testing for chemical tankers are given in Table 4.4.7.1.

4.4.7.2 All double bottom and peak tanks are to be tested in addition. The Surveyor may extend the tank testing as deemed necessary.

Table 4.4.7.1 : Table of minimum requirements for tank testing at special survey of chemical tankers

Special Survey No. I **Age ≤ 5**	**Special Survey No. II and subsequent** **Age > 5**
1. All ballast tank boundaries	1. All ballast tank boundaries
2. Cargo tank boundaries facing ballast tanks, void spaces, pipe tunnels, pump rooms or cofferdams	2. All cargo tank bulkheads

4.4.7.3 Boundaries of ballast tanks are to be tested with a head of liquid to the top of air pipes. Boundaries of cargo tanks are to be tested to the highest point that liquid will rise under service conditions.

4.4.7.4 Boundaries of fuel oil, lub.oil and fresh water tanks are to be tested with a head of liquid to the highest point that liquid will rise under service conditions. Tank testing of fuel oil, lub.oil and fresh water tanks may be specially considered based on a satisfactory external examination of the tank boundaries and a confirmation from the Master stating that the pressure testing has been carried out according to the requirement with satisfactory results.

4.4.7.5 The testing of double bottom tanks and other spaces not designed for the carriage of liquid may be omitted, provided a satisfactory internal examination together with an examination of the tank top is carried out.

4.4.7.6 Cargo tank testing carried out by the vessel's crew under the direction of the Master may be accepted by the surveyor subject to the approval of the Administration, provided the following conditions are complied with:

a) a tank testing procedure, specifying fill heights, tanks being filled and bulkheads being tested, taking into account the guidelines provided in the ESP Planning document, has been submitted by the owner and reviewed by IRS prior to the testing being carried out;

b) there is no record of leakage, distortion or substantial corrosion that would affect the structural integrity of the tank;

c) the tank testing has been satisfactorily carried out, in accordance with the reviewed procedure and the guidelines mentioned in a) above, within special survey window not more than 3 months prior to the date of the survey on which the overall or close up survey is completed;

d) the satisfactory results of the testing is recorded in the vessel's logbook;

e) the internal and external condition of the tanks and associated structure are found satisfactory by the surveyor at the time of the overall and close up survey.

4.4.8 Close-up survey requirements

4.4.8.1 The minimum requirements for Close-up Surveys at Special Survey are given in Table 4.4.8.1a) and Table 4.4.8.1b).

The survey of stainless steel tanks may be carried out as an overall survey supplemented by close-up survey as deemed necessary by the Surveyor.

4.4.8.2 The Surveyor may extend the Close-up Survey as deemed necessary taking into account the maintenance of the tanks under survey, the condition of the corrosion protection system and also in the following cases:

a) In particular, tanks having structural arrangements or details which have suffered defects on similar tanks or on similar ships according to available information.

b) In tanks which have structures approved with reduced scantlings due to an approved corrosion control system.

4.4.8.3 For areas in tanks where coatings are found to be in a GOOD condition, the extent of Close-up Surveys according to Table 4.4.8.1a) and Table 4.4.8.1b) may be specially considered by the Surveyor.

4.4.9 Thickness measurement

4.4.9.1 The minimum requirements for thickness measurements at Special Survey are given in Table 4.4.9.1.

4.4.9.2 Provisions for extended measurements for areas with Substantial Corrosion in case of Chemical Tankers are given in Table 4.4.9.2.

The Surveyor may further extend the thickness measurements as deemed necessary.

4.4.9.3 Transverse sections are to be chosen where the largest reductions are suspected to occur or are revealed from deck plating measurements.

In cases where two or three sections are to be measured at least one is to include a Ballast Tank within 0.5L amidships.

4.4.9.4 The thickness measurements are to be carried out by a qualified firm certified by IRS.

Table 4.4.8.1a) : Minimum requirements for close-up survey at special survey of single skin chemical tankers

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequently** **Age > 15**
A) **One Web Frame Ring** - in a ballast wing tank	A) **All Web Frame Rings** - in a ballast wing tank or double bottom ballast tank	A) **All Web Frame Rings** - in all ballast tanks	As Special Survey No.3
B) **One Deck Transverse** - in a cargo tank or on deck	B) **One Deck Transverse** - in each of the remaining ballast tank or on deck	A) **All Web Frames Rings** - in a cargo wing tank	Additional transverse areas as deemed necessary by the Surveyor
D) **One Transverse Bulkhead** – lower part in a ballast tank	B) **One Deck Transverse** - in a cargo wing tank or on deck	A) **One Web Frames Rings** - in each remaining cargo tank	
D) **One Transverse Bulkhead** - lower part in a cargo wing tank	B) **One Deck Transverse** – in two cargo center tanks or on deck	C) **All Transverse Bulkheads** - in all cargo and tanks	
D) **One Transverse Bulkhead** – lower part in a cargo center tank (See Note 1)	C) **Both Transverse Bulkhead** - in a ballast wing tank	C) **All Transverse Bulkheads** – in all ballast tanks	

Table 4.4.8.1a) : (Contd.)			
	D) **One Transverse Bulkhead** – lower part in each remaining ballast tank D) **One Transverse Bulkhead** - lower part in a cargo wing tank D) **One Transverse Bulkhead** - lower part in two cargo centre tanks (See Note 1)		
Note 1) Where no center cargo tanks are fitted (as in the case of center longitudinal bulkhead), transverse bulkheads in wing tanks are to be surveyed.			

A-D are areas subjected to close-up surveys and thickness measurements (See Fig.4.4.8.1 to 4.4.8.3)

A) Complete transverse web frame ring including adjacent structural members
B) Deck transverse including adjacent deck structural members
C) Transverse bulkhead complete - including girder system and adjacent members
D) Transverse bulkhead lower part - including girder system and adjacent structural members

Table 4.4.8.1b) : Minimum requirements for close-up survey at special survey of double skin chemical tankers

Special Survey No. I Age ≤ 5	**Special Survey No. II 5 < Age ≤ 10**	**Special Survey No. III 10 < Age ≤ 15**	**Special Survey No. IV and subsequently Age > 15**
1) **One Web Frame Ring** – in a ballast double hull tank (See Note 1)	1) **All Web Frame Rings** – in a ballast wing tank or ballast double hull tank (See Note 1)	1) **All Web Frame Rings** – in all ballast tanks	As special survey No.3
2) **One Deck Transverse** – in a cargo tank or on deck	6) **The Knuckle Area and the Upper Part** (3 metres approx.) of one web frame in each remaining ballast tank	7) **All Web Frame Rings** – in a cargo wing tank	Additional transverse areas as deemed necessary by the Surveyor
4) **One Transverse Bulkhead** – in a ballast tank (See Note 1)		7) **One Web Frame Ring** – in each remaining cargo tank	
5) **One transverse bulkhead** – in a cargo wing tank	2) **One Deck Transverse** – in two cargo tanks	3) **All Transverse Bulkheads** – in all cargo tanks	
5) **One Transverse Bulkhead** – in a cargo center tank (See Note II)	4) **One Transverse Bulkhead** – in each ballast tank (See Note I)	4) **All Transverse Bulkheads** – in all ballast tanks	

Table 4.4.8.1b) : (Contd.)

	5) **One Transverse Bulkhead** – in two cargo centre tanks (See Note II)		
	5) **One Transverse Bulkhead** – in cargo wing tank		

(1), (2), (3), (4), (5), (6) and (7) are areas to be subjected to close-up surveys and thickness measurements (See Figs. 4.4.8.1 to 4.4.8.3).

(1) Web frame in a ballast tank means vertical web in side tank, hopper web in hopper tank, floor in double bottom tank and deck transverse in double deck tank (where fitted), including adjacent structural members. In fore and aft peak tanks web frame means a complete transverse web frame ring including adjacent structural members.

(2) Deck transverse, including adjacent deck structural members (or external structure on deck in way of the tank, where applicable).

(3) Transverse bulkhead complete in cargo tanks, including girder system, adjacent structural members (such as longitudinal bulkheads) and internal structure of lower and upper stools, where fitted.

(4) Transverse bulkhead complete in ballast tanks, including girder system and adjacent structural members, such as longitudinal bulkheads, girders in double bottom tanks, inner bottom plating, hopper side, connecting brackets.

(5) Transverse bulkhead lower part in cargo tank, including girder system, adjacent structural members (such as longitudinal bulkheads) and internal structure of lower stool, where fitted.

(6) The knuckle area and the upper part (3 metres approximately), including adjacent structural members. Knuckle area is the area of the web frame around the connections of the slope hopper plating to the inner hull bulkhead and the inner bottom plating, upto 2 metres from the corners both on the bulkhead and the double bottom.

(7) Web frame in a cargo tank means deck transverse, longitudinal bulkhead structural elements and cross ties, where fitted, including adjacent structural members.

Note I : Ballast double hull tank : means double bottom tank plus double side tank plus double deck tank, as applicable, even if these tanks are separate.

Note II : Where no center cargo tanks are fitted (as in the case of center longitudinal bulkhead), transverse bulkheads in wing tanks are to be surveyed.

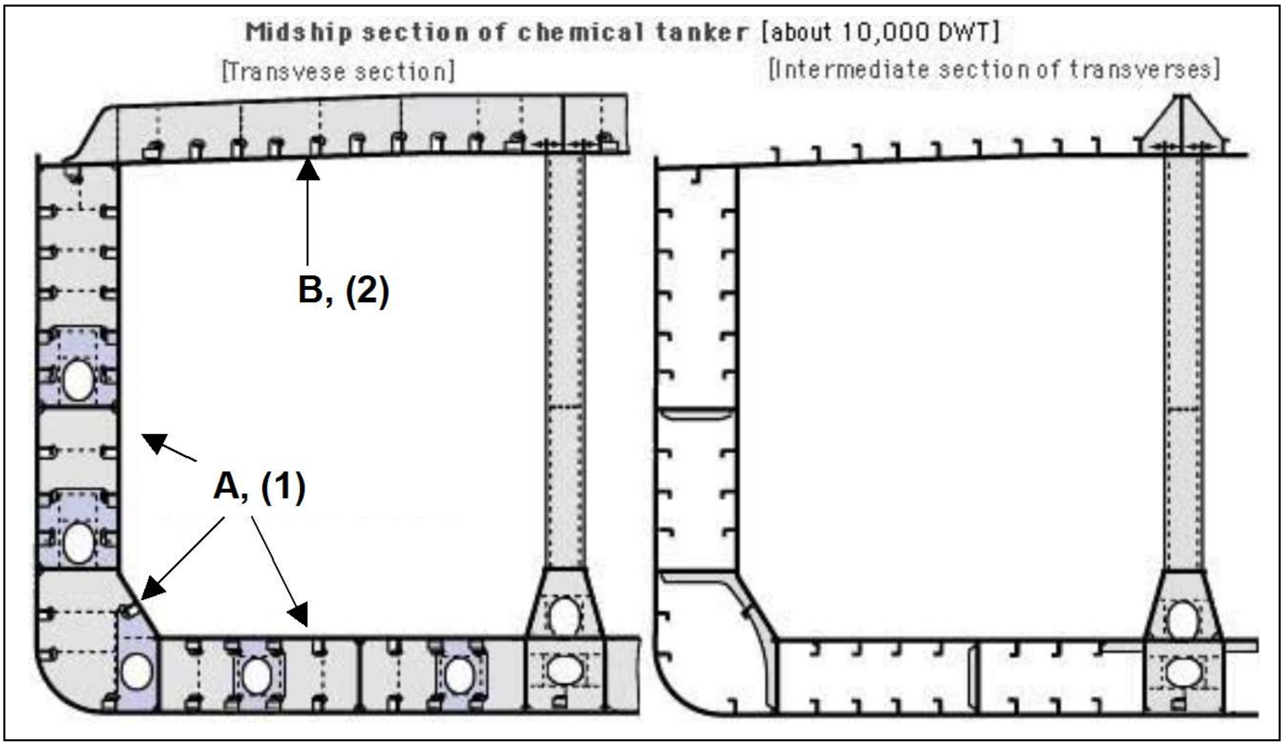

Fig. 4.4.8.1 : Representative transverse section of chemical tanker. Areas 1 and 2

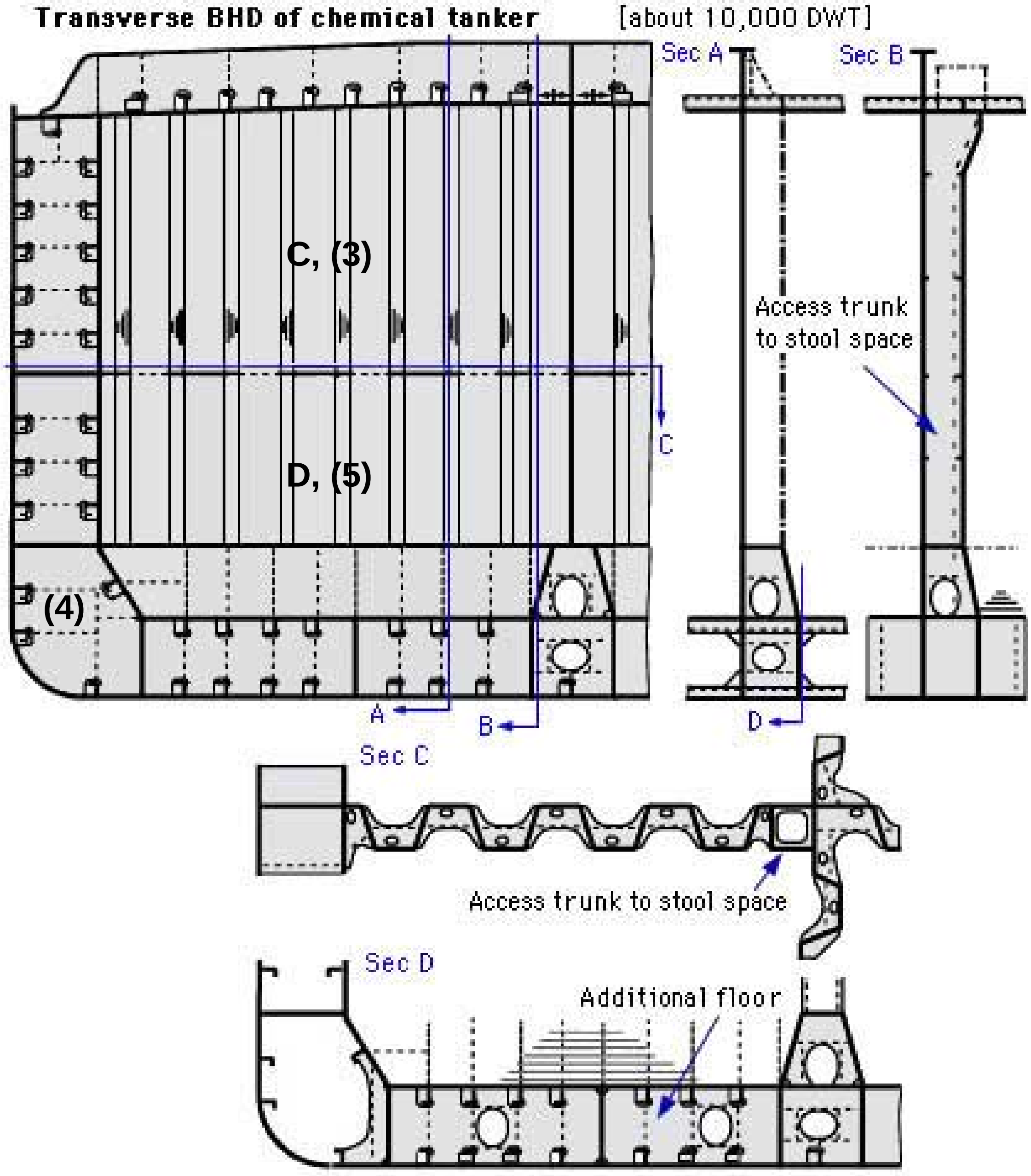

Fig. 4.4.8.2 : Representative transverse section of chemical tanker. Areas 3, 4 and 5

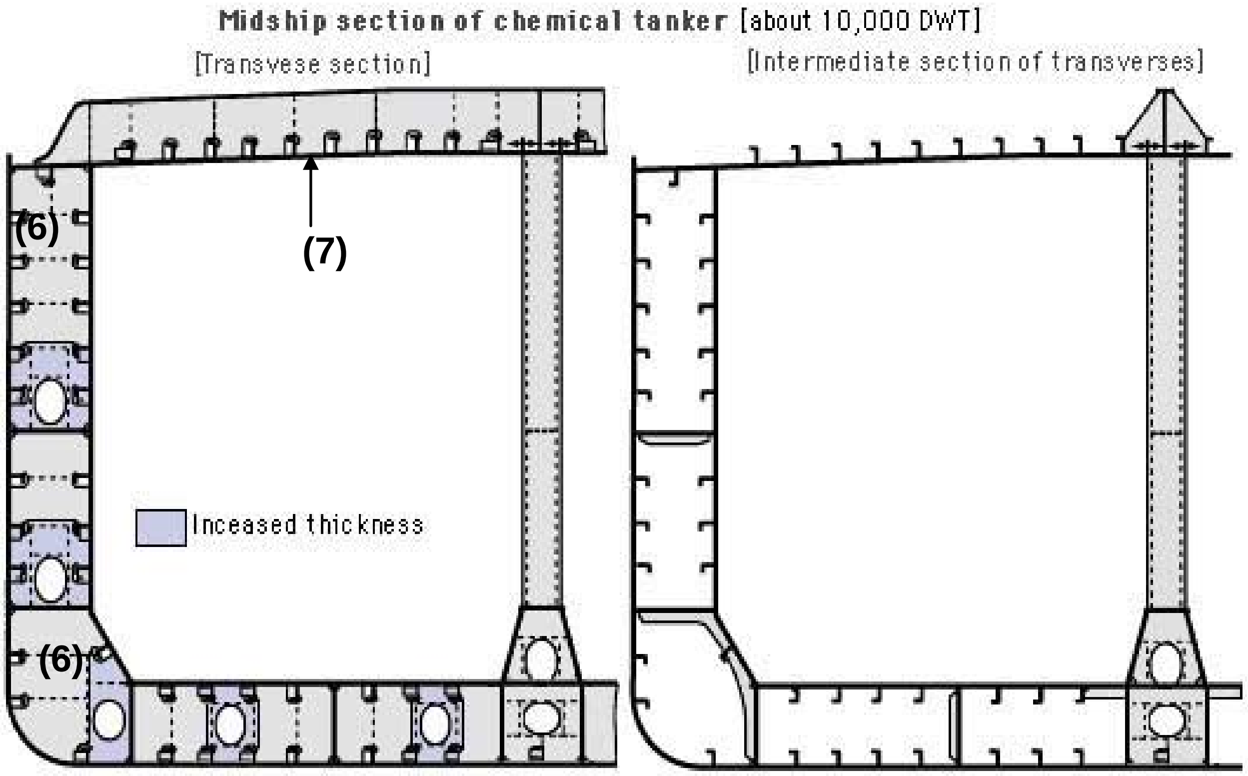

Fig. 4.4.8.3 : Representative transverse section of chemical tanker. Areas 6 and 7

Table 4.4.9.1 : Table of minimum requirements for thickness measurements at special survey of chemical tankers			
Special Survey No. I Age ≤ 5	**Special Survey No. II 5 < Age ≤ 10**	**Special Survey No. III 10 < Age ≤ 15**	**Special Survey No. IV and subsequently Age > 15**
1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel
2) Within the cargo area : One section of deck plating for the full beam of the ship (in way of a ballast tank, if any, or a cargo tank used primarily for water ballast)	2) Within the cargo area: a) Each deck plate b) One Transverse section	2) Within the cargo area: a) Each deck plate b)Two Transverse sections(1) c) All wind and water strakes	2) Within the cargo area: a) Each deck plate b) Three Transverse sections(1) c) All wind and water strakes d) Each bottom plate
3) Measurements of structural members subject to close-up survey according to Table 4.4.8.1a) and Table 4.4.8.1b), for general assessment and recording of corrosion pattern	3) Measurements of structural members subject to close-up survey according to Table 4.4.8.1a) and Table 4.4.8.1b), for general assessment and recording of corrosion pattern	3) Measurements of structural members subject to close-up survey according to Table 4.4.8.1a) and Table 4.4.8.1b), for general assessment and recording of corrosion pattern	3) Measurements of structural members subject to close-up survey according to Table 4.4.8.1a) and Table 4.4.8.1b), for general assessment and recording of corrosion pattern

Table 4.4.9.1 : (Contd.)

Special Survey No. I Age ≤ 5	Special Survey No. II 5 < Age ≤ 10	Special Survey No. III 10 < Age ≤ 15	Special Survey No. IV and subsequently Age > 15
	4) All wind and water strakes outside the cargo area	4) All wind and water strakes outside the cargo area	4) All wind and water strakes outside the cargo area
		5) Internals in forepeak and after peak tanks	5) Internals in forepeak and after peak tanks
			6) All exposed main deck plating outside cargo area
			7) Representative exposed superstructure deck plating (poop, bridge, forecastle deck)
			8) All keel plates, additional bottom plates in way of machinery space, aft end of tanks and cofferdams outside cargo area
			9) a) Plating of sea chests. b) Shell plating in way of overboard discharges as considered necessary by the Surveyor.
(1) At least one section is to include a ballast tank within 0.5L amidships			

Table 4.4.9.2 : Requirements for extent of thickness measurements at those areas of substantial corrosion, special survey of chemical tankers within the cargo area length

Structural member	Extent of measurement	Pattern of measurement
Bottom, inner bottom and hopper structure		
Bottom, inner bottom and hopper structure plating	Minimum of three bays across tank, including aft bay Measurements around and under all suction bell mouths	5-point pattern for each panel between longitudinals and floors
Bottom, inner bottom and hopper structure longitudinals	Minimum of three longitudinals in each bay where bottom plating measured	Three measurements in line across the flange and three measurements on vertical web
Bottom girders, including the watertight ones	At fore and aft watertight floors and in center of tanks	Vertical line of single measurements on girder plating with one measurement between each panel stiffener, or a minimum of three measurements. Two measurements across face flat where fitted
Bottom floors, including the watertight ones	Three floors in bays where bottom plating measured, with measurements at both ends and middle	5-point pattern over two square metre area

Table 4.4.9.2 : Contd.)		
Structural member	**Extent of measurement**	**Pattern of measurement**
Hopper structure web frame ring	Three floors in bays where bottom plating measured	5-point pattern over one square metre of plating. Single measurements on flange
Hopper structure transverse watertight bulkhead or swash bulkhead	- Lower 1/3 of bulkhead	- 5-point pattern over one square metre of plating
	- Upper 2/3 of bulkhead	- 5-point pattern over two square metre of plating
	- Stiffeners (minimum of three)	- For web, 5-point pattern over span (two measurements across web at each end and one at center of span). For flange, single measurements at each end and center of span
Panel stiffening	Where applicable	Single measurements
Deck structure		
Deck plating	Two transverse bands across tank	Minimum of three measurements per plate per band
Deck longitudinals	Every third longitudinal in each of two bands with a minimum of one longitudinal	Three measurements in line vertically on webs and two measurements on flange (if fitted)
Deck girders and brackets	At fore and aft transverse bulkhead, bracket toes and in centre of tanks	Vertical line of single measurements on web plating with one measurement between each panel stiffener, or a minimum of three measurements. Two measurements across flange, 5-point pattern on girder/bulkhead brackets
Deck transverse webs	Minimum of two webs, with measurements at both ends and middle of span	5-point pattern over one square metre area. Single measurements on flange
Vertical web and transverse bulkhead in wing ballast tank for double hull design (two metres from deck)	Minimum of two webs and both transverse bulkheads	5-point pattern over one square metre area
Panel stiffening	Where applicable	Single measurements
Side shell and longitudinal bulkheads		
Side shell and longitudinal bulkhead plating: - Deckhead and bottom strakes and strakes in way of horizontal girders - All other strakes	- Plating between each pair of longitudinals in a minimum of three bays (along the tank) - Plating between every third pair of longitudinals in same three bays	Single measurement

Table 4.4.9.2 : Contd.)		
Structural member	**Extent of measurement**	**Pattern of measurement**
Side shell and longitudinal bulkhead longitudinals on: - Deckhead and bottom strakes - All other strakes	- Each longitudinal in same three bays - Every third longitudinal in same three bays	3 measurements across web and 1 measurement on flange
Longitudinals – brackets	- Minimum of three at top, middle and bottom of tank in same three bays	5-point pattern over area of brackets
Vertical web and transverse bulkheads of double side tanks (excluding deck area): - Strakes in way of horizontal girders - Other strakes	- Minimum of two webs and both transverse bulkheads - Minimum of two webs and both transverse bulkheads	- 5-point pattern over approx. two square metre area - Two measurements between each pair of vertical stiffeners
Web frames and cross ties for other tanks than double side tanks	Three webs with minimum of three locations on each web, including in way of cross tie connections and lower end brackets	5-point pattern over approximately two square metre area of webs, plus single measurements on flanges of web frame and cross ties
Horizontal girders	Plating on each girder in a minimum of three bays	Two measurements between each pair of longitudinal girder stiffeners
Panel stiffening	Where applicable	Single measurements
Transverse watertight and swash bulkheads		
Upper and lower stool, where fitted	- Transverse band within 25 [mm] of welded connection to inner bottom / deck plating - Transverse band within 25 [mm] of welded connection to shelf plate	5-point pattern between stiffeners over one metre length
Deckhead and bottom strakes and strakes in way of horizontal stringers	Plating between pair of stiffeners at three locations: approximately ¼, ½ and ¾ width of tank	5-point pattern between stiffeners over one metre length
All other strakes	Plating between pair of stiffeners at middle location	Single measurement
Strakes in corrugated bulkheads	Plating for each change of scantling at center of panel and at flange of fabricated connection	5-point pattern between stiffeners over one metre length
Stiffeners	Minimum of three typical stiffeners	For web, 5-point pattern over span between bracket connections (two measurements across web at each bracket connection and one at center of span). For flange, single measurements at each bracket toe and at center of span

Table 4.4.9.2 : Contd.)		
Structural member	**Extent of measurement**	**Pattern of measurement**
Brackets	Minimum of three at top, middle and bottom of tank	5-point pattern over areas of bracket
Horizontal stringers	All stringers with measurements at both ends and middle	5-point pattern over one square metre areas, plus single measurements near bracket toes and on flanges
Deep webs and girders	Measurements at toe of bracket and at center of span	For web, 5 point pattern over about 1 square metre, 3 measurements across face flat

4.4.9.5 In order to ensure necessary control during the process of thickness measurements, these are normally to be carried out under the supervision of the Surveyor. The Surveyor has the right to re-check the measurements as deemed necessary to ensure acceptable accuracy.

4.4.9.6 In all cases the extent of the thickness measurements are to be sufficient as to represent the actual average condition.

4.4.9.7 A thickness measurement report is to be prepared. The report is to give the location of measurements, the thickness measured as well as corresponding original thickness. Furthermore, the report is to give the date when the measurements were carried out, type of measuring equipment, names of personnel and their qualifications and has to be signed by the operator. The Surveyor is to review the report of the final thickness measurement after repairs have been carried out and countersign the cover page.

4.4.10 Additional requirements for cargo and ballast piping

4.4.10.1 For chemical tankers exceeding 10 years of age selected steel cargo pipes outside cargo tanks and ballast pipes passing through cargo tanks are to be:

- Thickness measured at random or selected pipe lengths to be opened for internal inspection.

- Pressure tested to the maximum working pressure. Special attention is to be given to cargo/slop discharge piping through ballast tanks and void spaces.

4.4.11 Survey of independent tanks

4.4.11.1 All independent cargo tanks are to be surveyed internally and externally together with tank supports and the adjacent hull structure.

4.4.11.2 Thickness gauging of the independent cargo tanks is to be carried out as found necessary by the Surveyor.

4.4.11.3 All independent cargo tanks are to be hydraulically pressure tested to their MARVS (Maximum Allowable Relief Valve Setting). However, testing of gravity type tanks may be omitted if the tanks are found without corrosion and other damages and otherwise acceptable.

4.4.12 Reporting and evaluation of survey

4.4.12.1 The data and information on the structural condition of the vessel collected during the survey is to be evaluated for acceptability and continued structural integrity of the vessel.

4.4.12.2 An Executive Hull Summary of the survey and results is to be issued to the Owner and placed on board the vessel for reference at future surveys. The Executive Hull Summary is to be endorsed by IRS Head Office.

4.5 Special Surveys - Machinery

4.5.1 Requirements for examination of machinery and systems are given in Sec.8.

Section 5

Surveys - Liquefied Gas Carriers

5.1 Scope

5.1.1 This section gives the requirements for periodical surveys of vessels which have been assigned the class notation:

Liquefied gas carrier.

5.2 Annual surveys

5.2.1 General

5.2.1.1 Annual Surveys are to be carried out within 3 months before or after the anniversary date each year. These should be held concurrently with statutory annual or other relevant statutory Surveys, where practicable.

5.2.1.2 At Annual Surveys, the Surveyor is to examine the hull and machinery, so far as necessary and practicable, in order to be satisfied as to their general condition.

5.2.1.3 The annual survey is preferably to be carried out during a loading or unloading operations.

5.2.1.4 It is to be confirmed that no new installation of material containing asbestos was carried out since last survey.

5.2.2 Hull and weather deck

5.2.2.1 The survey is to consist of an examination for the purpose of ensuring, as far as practicable, that the hull, equipment, closing appliances and related piping are maintained in satisfactory/efficient condition. Special attention is to be paid to the following:

a) Weather deck, shipside plating above waterline.

b) Openings on freeboard and superstructure decks; exposed casings; skylights and fiddley openings; deck houses; companionways and superstructure bulkheads; side scuttles and dead lights; flush deck scuttles; ash shoots and other openings.

c) Weld connection between air pipes and deck plating; air pipe heads on exposed decks (external examination); flame screens on vents to all bunker tanks; ventilators and closing devices.

d) Watertight bulkheads and their penetrations as far as practicable.

e) Scuppers and sanitary discharges as far as practicable together with valves and their controls.

f) Guard rails, bulwarks, freeing ports, gangways, walkways and life lines.

g) Examining the cargo, bunker, ballast and vent piping systems, including vent masts and protective screens, as far as practicable.

h) Confirming that the wheel house doors and windows, non-opening type side scuttles and windows in superstructure and deck house ends facing the cargo area are in a satisfactory gastight condition.

i) Confirming that any special arrangements to survive conditions of damage are in order.

5.2.2.2 Examining the cargo compressor rooms and electrical motor rooms.

Examination of the electric motor room and compressor room bulkheads for signs of leakage or fractures and in particular, the sealing arrangements of all penetrations on bulkheads.

5.2.2.3 Confirming that the sealing arrangements at the gas domes are satisfactory.

5.2.2.4 All watertight doors in watertight bulkheads, to be examined and tested (locally and remotely) as far as practicable.

5.2.2.5 Suspect areas identified at previous special or intermediate surveys are to be close-up surveyed. Thickness measurements are to be taken in the area of substantial corrosion identified at previous surveys.

5.2.2.6 Examination of ballast tanks is to be carried out when required as a consequence of the results of the Special Survey or Intermediate Survey. (See 5.4.3.5, 5.4.3.6, 5.3.2.1 and 5.3.2.2). When considered necessary by the Surveyor or where extensive corrosion is found, thickness measurement is to be carried out. When examination of ballast tanks reveals substantial corrosion, additional thickness measurements are to be carried out to determine the extent of the areas of substantial corrosion in accordance with Table 5.4.4.2.

5.2.2.7 Anchoring and mooring equipment is to be examined as far as is practicable. A general examination of the emergency towing arrangements is to be carried out to ensure their ready availability.

For vessels with single point mooring arrangements where 'SPM' notation is assigned, the following are to be generally examined:

a) Components of the single point mooring system (bow chain stoppers, bow fairleads, pedestal roller fairleads, winches and capstans), to verify their satisfactory condition.

b) Hull structures supporting and adjacent to the components of the single point mooring system, to verify that there is no deformation or fracture.

5.2.2.8 Where applicable Surveyor should satisfy himself regarding the freeboard marks on the ship's side.

5.2.2.9 The Surveyor is to confirm that, where required, an approved loading instrument together with its operation manual are available on board, See Pt.3, Ch.5. It is to be verified by the Surveyor that the loading instrument is checked for accuracy at regular intervals by the ship's staff by applying test loading conditions.

5.2.2.10 Accommodation ladders are to be examined at annual surveys. Satisfactory condition of the following items is to be checked, in particular :

a) steps;
b) platforms;
c) all support points such as pivots, rollers, etc.;
d) all suspension points such as lugs, brackets, etc.;
e) stanchions, rigid handrails, hand ropes and turntables;
f) davit structure, wire and sheaves, etc.

5.2.2.11 Gangways are to be examined at annual surveys. Satisfactory condition of the following items is to be checked, in particular :

a) treads;
b) side stringers, cross-members, decking, deck plates, etc.;
c) all support points such as wheel, roller, etc.;
d) stanchions, rigid handrails, hand ropes.

5.2.2.12 Winches of accommodation ladders and gangways are to be examined to verify the satisfactory condition of the following items:

a) brake mechanism including condition of brake pads and band brake, if fitted;
b) remote control system, and
c) power supply system for electric motor.

5.2.2.13 Davits and fittings on the ship’s deck associated with accommodation ladders and gangways are to be examined for satisfactory condition at annual surveys. Fittings or structures for means of access to deck such as handholds in a gateway or bulwark ladder and stanchions are also to be examined.

5.2.2.14 The maintenance and inspection records of accommodation ladders and gangways are to be verified. It is to be confirmed that supporting wires are being renewed at intervals not exceeding 5 years.

5.2.2.15 When examining internal spaces, as far as practicable, the permanent means of access where appropriate, are to be verified that they remain in good condition.

5.2.2.16 For vessels subject to IMO PSPC (See Pt.3, Ch.2, 3.6) it is to be confirmed that the maintenance, repair and partial re-coating of dedicated ballast tanks, as appropriate, are recorded in the coating technical file.

5.2.3 Machinery and systems

5.2.3.1 A general examination of the machinery, boilers, all pressurised systems (steam, hydraulic, pneumatic) and their associated fittings, propulsion system and auxiliary machinery to see whether they are being properly maintained and with particular attention to the fire and explosion hazards.

5.2.3.2 Confirmation that machinery, boilers and other pressure vessels, associated piping systems and fittings are so installed and protected as to reduce to a minimum any danger to persons on board, due regard being given to moving parts, hot surfaces and other hazards.

5.2.3.3 Confirmation that Periodical Surveys of boilers and other pressure vessels have been carried out as required by the Rules and the safety devices have been tested.

5.2.3.4 Confirmation that the normal operation of the propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative.

5.2.3.5 Confirmation that means are provided so that machinery can be brought into operation from the dead ship condition without external aid.

5.2.3.6 All main and auxiliary steering arrangements and their associated equipment and control systems are to be examined and tested. Where applicable, Surveyors are to verify that log entries have been made in accordance with statutory requirements.

5.2.3.7 Confirming, when appropriate, that requisite arrangements to regain steering capability in the event of the prescribed single failure are being maintained.

5.2.3.8 All the means of communication between the navigating bridge and the machinery control positions, as well as the bridge and the main alternative steering position, if fitted, are to be tested. It is to be confirmed that means of indicating the angular position of the rudder are operating satisfactorily.

5.2.3.9 Confirmation that with ships having emergency steering positions there are means of relaying heading information and, when appropriate, supplying visual compass readings to the emergency steering positions.

5.2.3.10 Confirmation that various alarms required for hydraulic power operated, electric and electro-hydraulic steering gears are, operating satisfactorily and that the recharging arrangements for hydraulic power operated steering gears are being maintained.

5.2.3.11 Examining the means for the operation of the main and auxiliary machinery essential for propulsion and the safety of the ship, including when applicable, the means of remotely controlling the propulsion machinery from the navigating bridge and the arrangements to operate the main and other machinery from a machinery control room.

5.2.3.12 Confirmation that the engine room telegraph, the second means of communication between the navigation bridge and the machinery space and the means of communication with any other positions from which the engines are controlled are operating satisfactorily.

5.2.3.13 Confirmation that the engineer's alarm is clearly audible in the engineer's accommodation.

5.2.3.14 The bilge pumping systems and bilge wells including operation of each bilge pump, extended spindles and level alarms, where fitted, are to be examined as far as is practicable. It is also to be confirmed that bilge pumping system for each watertight compartment is satisfactory.

It is also to be confirmed that drainage from enclosed spaces in cargo areas situated on freeboard deck is satisfactory.

5.2.3.15 Examining visually the condition of any expansion joints in sea water system.

5.2.3.16 General examination visually and in operation, as feasible, of the main electrical machinery, the emergency sources of electrical power, the switch gear, other electrical equipment including the lighting system is to be carried out.

5.2.3.17 Confirmation as far as practicable, the operation of the emergency source(s) of electrical power, including their starting arrangement, the systems supplied, and when appropriate, their automatic operation.

5.2.3.18 Examining in general, that the precautions provided against shock, fire and other hazards of electrical origin are being maintained.

5.2.3.19 General Examination of automation equipment is to be carried out. Satisfactory operation of safety devices, bilge level detection and alarm systems and control systems is to be verified.

5.2.3.20 Confirmation that machinery space ventilation systems are in good working condition.

5.2.4 Fire protection, detection and extinction

5.2.4.1 The arrangements for fire protection, detection and extinction are to be examined and are to include confirmation that no changes have been made in the structural fire protection. Following are to be examined / verified:

a) verification that fire control plans are properly posted;

b) examination as far as possible and testing as feasible of the fire and/or smoke detection system(s);

c) examination of the fire main system and verification that each fire pump including the emergency fire pump can be operated separately so that the two required powerful jets of water can be produced simultaneously from different hydrants; testing the remote means for starting one main fire pump;

d) verification that fire hoses, nozzles, applicators and spanners are in good working condition and situated at their respective locations;

e) examination of fixed fire fighting system controls, piping, instructions and marking, checking for evidence of proper maintenance and servicing including date of last systems tests;

f) verification that all semi-portable and portable fire extinguishers are in their stowed positions, checking for evidence of proper maintenance and servicing, conducting random check for evidence of discharged containers;

g) verification, as far as practicable, that the remote controls for stopping fans and machinery and shutting off fuel supplies in machinery spaces are in working order;

h) examination of the closing arrangements of ventilators, funnel annular spaces, skylights, doorways and tunnel, where applicable;

i) confirmation that the fire fighters' outfits and emergency escape breathing devices (EEBDs) are complete and in good condition and that the cylinders, including the spare cylinders, of any required self-contained breathing apparatus are suitably charged;

j) examination of any manual and automatic fire doors and proving their operations;

k) Examining the fixed fire fighting system for the cargo pump room and confirming that its means of operation is clearly marked;

l) Examining the water spray system for cooling, fire protection and crew protection and confirming that its means of operation is clearly marked;

m) Confirming that electrical equipment in gas dangerous spaces and zones is in satisfactory condition and properly maintained;

n) Examining the dry chemical powder fire extinguishing system for the cargo area and confirming that its means of operation is clearly marked;

o) Examining the fixed fire fighting system for the cargo pump room and the deck foam system for the cargo area and confirming that their means of operation are clearly marked.

p) examination of the fire-extinguishing systems for spaces containing paint and/or flammable liquids and deep fat cooking equipment in accommodation and service spaces;

q) examination of the fire safety requirements of any helicopter facilities.

Surveys carried out by the National Authority of the country in which the ship is registered would normally be accepted as meeting these requirements, at the discretion of the Surveyor.

5.2.4.2 On ships where inert gas systems are installed, the requirements of Sec.12 are to be complied with.

5.2.4.3 Confirmation that the means of escape from accommodation, machinery spaces and other spaces are satisfactory.

5.2.4.4 Examination of the arrangements for gaseous fuel for domestic purposes.

5.2.5 Other safety arrangements related to cargo / cargo area

5.2.5.1 The ship's log and operational records for the cargo containment system covering the period from the previous survey are to be examined taking into consideration hours per day of the reliquefaction plant or the boil-off rate. Any malfunction of the system entered in the log is to be investigated, the cause ascertained, and that part of the system at fault is to be found or placed in good order.

5.2.5.2 Cargo liquid level indicating devices are to be generally examined. The low level, high level, and overfill alarms are to be examined and tested to ascertain that they are in working order. Consideration will be given to the acceptance of simulated tests, provided that they are carried out at the cargo temperature, or comprehensive maintenance records, including details of tests held, in accordance with the cargo plant instrumentation maintenance manual. The calibration status of the measuring instruments may also be verified.

5.2.5.3 Cargo gas leakage detection systems are to be examined and tested to ascertain that they are in working order and calibrated using sample gas.

The gas detection arrangements for cargo control rooms and the measures taken to exclude ignition sources where such spaces are not gas safe, are to be examined.

5.2.5.4 The correct functioning of the cargo containment system temperature and pressure indicating equipment, together with any associated alarms, is to be verified.

5.2.5.5 Control devices for the cargo containment systems and cargo handling equipment, together with any associated shutdown and/or interlock, are to be checked under simulated working conditions and, if necessary, recalibrated.

5.2.5.6 The arrangements for manually operated emergency shutdown system together with the automatic shut down of the cargo pumps and compressors are to be checked to ascertain they are in working order.

Alternatively, the log books may be examined for verification that the emergency shutdown system has been tested.

5.2.5.7 Ventilation systems and air locks in working spaces are to be checked for satisfactory operation.

5.2.5.8 Cargo pipeline, valves and fittings are to be generally examined, with special reference to expansion bellows, supports and vapour seals on insulated pipes.

5.2.5.9 Examining the process piping including the expansion arrangements, insulation from hull structure, pressure relief and drainage arrangements.

5.2.5.10 Portable and/or fixed drip trays, or insulation for deck protection in the event of cargo leakage, are to be examined for condition.

5.2.5.11 Examining when applicable bow or stern loading and unloading arrangements with particular reference to the electrical equipment, fire- fighting arrangements and means of communications between the cargo control room and the shore location.

5.2.5.12 Confirming that the cargo tank and interface pressure and relief valves, including safety systems and alarms are satisfactory.

5.2.5.13 Confirming that all liquid and vapour hoses are suitable for their intended purpose.

5.2.5.14 Confirming that any air drying system and any inter barrier and hold space purging inert gas system are satisfactory.

For membrane containment systems, normal operation of the nitrogen control system for insulation and inter barrier spaces is to be confirmed by the Master.

5.2.5.15 Confirming that two sets of portable gas detection equipment suitable for the cargoes to be carried and a suitable instrument for measuring oxygen levels have been provided.

5.2.5.16 Electrical bonding of the cargo pipes and tanks to the hull is to be verified.

5.2.5.17 Confirming that when applicable arrangements are made for sufficient inert gas to be carried to compensate for normal losses and that means are provided for monitoring the spaces.

5.2.5.18 Confirming that the use of inert gas has not increased beyond that needed to compensate for normal losses by examining records of inert gas usage.

5.2.6 Reliquefaction/refrigeration equipment

5.2.6.1 Where reliquefaction or refrigeration equipment for cargo temperature and pressure control is fitted and notation HY(LGC) assigned, the following are to be examined, so far as is practicable:

a) The machinery under working conditions.

b) The shells of all pressure vessels in the system, externally, insulation need not be removed for this examination, but any deterioration of insulation or evidence of dampness which could lead to external corrosion of the vessels of their connections, is to be investigated.

c) Primary refrigerant gas and liquid pipes, cargo vapour and liquid condensate pipes and condenser cooling water pipes. Insulation need not be removed, but any deterioration or evidence of dampness is to be investigated.

d) The reliquefaction/refrigeration plant spare gear.

5.2.7 Methane burning equipment and other equipment components

5.2.7.1 The following components are to be generally examined externally. If insulation is fitted, this need not be removed, but any deterioration of insulation, or evidence of dampness which could lead to external corrosion of the vessels or their connections, is to be investigated.

a) Heat exchangers and pressure vessels for use with methane burning in boilers or machinery.

b) Cargo heaters, vaporizers, masthead heaters and other miscellaneous pressure vessels.

5.2.7.2 Controls and interlocks are to be checked.

5.2.7.3 Alarm systems are to be checked to ascertain they are in working order.

5.2.7.4 Exhaust fans and/or pressurizing system for gas trunking are to be tested.

5.2.7.5 The relevant instruction and information material such as cargo handling plans, filling limit information, cooling down procedures etc. are to be verified as being onboard.

5.2.8 Cargo containment systems

5.2.8.1 At the first Annual Survey after initial commissioning of the ship, the operating records of the primary gas detection system are to be examined.

5.2.8.2 Where the insulation arrangement is such that the insulation cannot be examined during special surveys (See 5.4.6.9) the surrounding structures of wing tanks, double bottom tanks and cofferdams are to be examined for cold spots, prior to the survey. This examination is to be held at a convenient cargo discharge operation with the cargo tanks loaded at approximately the minimum notation temperature.

5.2.8.3 On application by the Owner, consideration will be given to the cold spot examination, where applicable, being carried out by the ship's staff.

5.2.8.4 When tests are required after repairs, independent cargo tanks, other than independent tanks, type C, are to be tested by hydraulic or hydropneumatic means as appropriate. Test heads and pressures should be as defined in Pt.5, Ch.4. Cargo tanks of the membrane or semi-membrane type are to be tested by means of a detectable gas in the inter-barrier spaces and discolouring paint on the weld seams of the cargo tanks wall, or other suitable means. Independent cargo tanks of type C are to be tested hydraulically at 1.25 times the approved maximum vapour pressure.

5.2.9 Personnel protection

a) Verification that the requisite safety equipment and associated breathing apparatus with requisite air supplies and emergency escape respiratory and eye protection, if required, are in good condition and are properly stowed.

b) Verification that medical first air equipment including stretchers and oxygen resuscitation is in god condition and that satisfactory arrangements are made for antidotes for cargoes actually carried to be on board.

c) Verification that decontamination arrangements are operational.

5.3 Intermediate Surveys

5.3.1 General

5.3.1.1 Intermediate surveys are to be carried out at or between the second or third Annual Survey. However, only those items which are additional to the requirements for annual surveys may be examined between the second or third annual surveys.

Concurrent crediting to both Intermediate survey and Special survey for surveys and thickness measurements of spaces is not acceptable.

5.3.1.2 The following requirements are applicable for vessels over five years of age. For vessels below 5 years of age additional examination over and above the requirements of Annual survey may be required at the discretion of the Surveyors.

5.3.1.3 For ships carrying liquefied gases in bulk the intermediate survey is preferably to be carried out with the ship in a gas free condition. The purpose of the intermediate survey is to supplement the annual survey by testing the cargo handling installations with related automatic control, alarm and safety systems for their correct functioning. The extent of the testing required for the intermediate survey will normally be such that the survey cannot be carried out during loading or discharging operation.

5.3.1.4 Prior to the commencement of any part of the intermediate survey, a survey planning meeting is to be held between the attending Surveyor(s), the owner's representative in attendance and where involved, the thickness measurement company representative and the master of ship or an appropriately qualified representative appointed by the master or Company for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

5.3.2 Ballast tanks

5.3.2.1 Vessels of age more than 5 years but not exceeding 10 years

a) An overall survey of representative ballast tanks is to be carried out. When extensive corrosion is found, thickness measurements are to be carried out. If such examination reveals no visible structural defects, the examination may be limited to a verification that the corrosion prevention system remain efficient.

b) Where POOR coating condition, corrosion or other defects are found in ballast spaces or where hard protective coating was not applied from the time of construction, the examination is to be extended to other ballast spaces of the same type.

c) For ballast tanks, other than double bottom tanks, where a protective coating is found to be in POOR condition and is not renewed, where a soft or semi-hard coating has been applied or where a hard protective coating was not applied from the time of construction, the tank(s) in question are to be examined at subsequent annual surveys.

d) For double bottom ballast tanks, where a protective coating is found to be in POOR condition and is not renewed, where a soft or semi-hard coating has been applied or where a hard protective coating was not applied from the time of construction, the tank(s) in question may be examined at subsequent Annual surveys.

5.3.2.2 Vessels of age more than 10 years

a) An internal general examination of all ballast tanks is to be carried out. When extensive corrosion is found, thickness measurements are to be carried out. If such examination reveals no visible structural defects, the examination may be limited to a verification that the corrosion prevention system remain efficient.

b) For ballast tanks, other than double bottom tanks, where a protective coating is found to be in POOR condition and is not renewed, where a soft or semi-hard coating has been applied or where a hard protective coating was not applied from the time of construction, the tank(s) in question are to be examined at subsequent annual surveys.

c) For double bottom ballast tanks, where a protective coating is found to be in POOR condition and is not renewed, where a soft or semi-hard coating has been applied or where a hard protective coating was not applied from the time of construction, the tank(s) in question may be examined at subsequent Annual surveys.

d) The Surveyor is to carry out a Close-up survey and thickness measurement of structure identified at the previous Special Survey as having substantial corrosion. The minimum requirements for close-up surveys at intermediate survey are given in Table 5.3.2.2.

5.3.3 Safety arrangements related to cargo

5.3.3.1 The following are to be dealt with as applicable:

a) Examination of means for draining the vent piping system.

b) Verification that the heating arrangements, if any, for steel structures are satisfactory.

c) With regard to the Cargo containment systems examination of the items in accordance with 5.2.8.1 and 5.2.8.2.

d) Cargo tank and inter-barrier space pressure and vacuum relief valve settings are to be checked and adjusted as required. Cargo tank pressure relief valve harbour settings are also to be checked, if applicable. A check is to be made that cargo tank pressure relief valves will lift at a pressure not more than the percentage given below, above the maximum vapour pressure for which the tanks have been approved.

For 0 to 1.5 bar - 10 per cent.
For 1.5 to 3.0 bar - 6 per cent.
For pressure exceeding 3.0 bar - 3 per cent.

Valves may be removed from the tanks for the purpose of checking.

Table 5.3.2.2 : Table of the minimum requirements for close-up survey of hull at intermediate surveys of liquefied gas carriers

10 < age ≤ 15	**age > 15**
Close-up survey of: - all web frames and both transverse bulkheads in a representative ballast tank (1) and (2) - the upper part of one web frame in another representative ballast tank - one transverse bulkhead in another representative ballast tank (2)	Close-up survey of : - all web frames and both transverse bulkheads in two representative ballast tanks (1) and (2)
(1) Complete transverse web frame including adjacent structural members	
(2) Transverse bulkhead complete, including girder system and adjacent members and adjacent longitudinal bulkhead structure	
Note 1 : Ballast tanks include topside, double hull side, double bottom, hopper side or any combined arrangement of the aforementioned and peak tanks where fitted.	
Note 2 : For areas in tanks where protective coating is found to be in good condition, the extent of close-up survey may be specially considered.	
Note 3 : For ships having independent tanks of type C, with a midship section similar to that of a general cargo ship, the extent of close-up surveys may be specially considered.	
Note 4 : The extent of close-up surveys may be extended by the Surveyor as deemed necessary, taking into account the maintenance of the tanks under survey, the condition of the corrosion prevention system and also in the following cases: - in particular, in tanks having structural arrangements or details which have suffered defects in similar tanks, or on similar ships according to available information; - in tanks having structures approved with reduced scantlings.	

e) Generally examining the electrical equipment and cables in dangerous zones such as cargo pump rooms and areas adjacent to cargo tanks to check for defective equipment, fixtures and wiring. The insulation resistance of the circuits is to be tested and in cases where a proper record of testing is maintained, consideration should be given to accepting recent readings. Examination with reference to the following is to be carried out:

- Protective earthing (spot check).
- Integrity of flame proof enclosures.
- Damage of outer sheath of cables.
- Function testing of pressurized equipment and associated alarms.
- Testing of systems for de-energizing non-certified safe electrical equipment located in spaces protected by air locks, such as electrical motor-rooms, cargo control rooms, etc.

f) Confirming that spares are provided for cargo area mechanical ventilation fans.

g) Checking the provision of equipment for personnel protection.

h) Examining when applicable, the arrangements for the use of cargo as fuel and testing as far as practicable, that the gas supply to the machinery space is cut off should the exhaust ventilation not be functioning correctly and that the master gas fuel valve may be remotely closed from within the machinery space.

i) The emergency shutdown system is to be tested without flow in the pipelines, to verify that the trip system stops the cargo pumps and compressors.

5.4 Special Surveys - Hull

5.4.1 General

5.4.1.1 All ships classed with IRS are to undergo Special Surveys at 5 yearly intervals. The first Special Survey is to be completed within 5 years from the date of the initial classification survey and thereafter 5 years from the assigned date of the previous Special Survey. However, an extension of class of 3 months maximum beyond the 5^{th} year may be granted in exceptional circumstances in accordance with 1.11. In such cases, the next period of class will start from the expiry date of the Special Survey before extension was granted.

Concurrent crediting to both Intermediate survey and Special survey for surveys and thickness measurements of spaces is not acceptable.

5.4.1.2 The interval between the Special Surveys may be reduced at the request of the parties concerned or by IRS if considered appropriate.

5.4.1.3 For surveys completed within 3 months before the expiry date of the Special Survey, the next period of class will start from the expiry date of the Special Survey. For surveys completed more than 3 months before the expiry date of the Special Survey, the period of class will start from the survey completion date. In cases where the vessel has been laid up or has been out of service for a considerable period because of a major repair or modification and the owner elects to only carry out the overdue surveys, the next period of class will start from the expiry date of the special survey. If the owner elects to carry out the next due special survey, the period of class will start from the survey completion date. Any requirement of the Flag Administration in this regard is also to be complied with.

5.4.1.4 The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date. When the special survey is commenced prior to the fourth annual survey, the entire survey is to be completed within 15 months if such work is to be credited to the special survey and in this case the next period of class will start from the survey completion date.

5.4.1.5 For the purpose of special survey, results of thickness measurement carried out during or after the fourth annual survey only would be considered.

5.4.1.6 Record of Special Survey will not be assigned until the Machinery Survey has been completed or postponed in agreement with IRS.

5.4.1.7 Ships which have satisfactorily passed a Special Survey will have a record entered in the Supplement to the Register Book indicating the assigned date of Special Survey.

5.4.1.8 The special survey is to include, in addition to the requirements of the Annual Survey, examination, tests and checks of sufficient extent to ensure that the hull, equipment and related piping are in satisfactory condition and that the ship is fit for its intended purpose for the new period of class of five years to be assigned subject to proper maintenance and operation and the periodical surveys being carried out at the due dates.

5.4.1.9 The examinations of the hull are to be supplemented by thickness measurements (See 5.4.4) and testing as deemed necessary, to ensure that the structural integrity remains effective. The aim of the examination is to discover substantial corrosion, significant deformation, fractures, damages or other structural deterioration, that may be present.

5.4.1.10 A Docking Survey in accordance with the requirements of Sec.7 is to be carried out as part of the Special Survey. Any remaining work in respect of the overall and close-up surveys and thickness measurements and repairs applicable to the lower portions of ballast tanks (i.e. parts below light ballast waterline) are to be completed in the dry dock

5.4.2 Planning and preparation for survey

5.4.2.1 The ship is to be prepared for overall survey in accordance with the requirements of Table 5.4.2.1. The preparation is to be of sufficient extent to facilitate an examination to ascertain any excessive corrosion, deformation, fractures, damages and other structural deterioration.

5.4.2.2 Prior to commencement of any part of the special survey, a survey planning meeting is to be held between the attending surveyor(s), the owner's representative in attendance, the thickness measurement company representative and the master of the ship or an appropriately qualified representative appointed by the master or Company for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

5.4.3 Examination and testing

5.4.3.1 All spaces within the hull and superstructure are to be examined.

5.4.3.2 All tanks other than cargo and ballast tanks are to be examined internally in accordance with the requirements of Table 5.4.3.2.

All bilge and ballast piping systems are to be examined and operationally tested to working pressure to attending Surveyor's satisfaction to ensure that tightness remains satisfactory.

5.4.3.3 An overall survey of all water ballast tanks including double bottom tanks, cargo compressor and electrical motor rooms, pipe tunnels, cofferdams and void spaces bounding cargo tanks, decks and outer hull is to be carried out. This examination is to be supplemented by thickness measurement and testing as deemed necessary, to ensure that the structural integrity remains effective. The aim of the examination is to discover Substantial Corrosion, significant deformation, fractures, damages or other structural deterioration and if deemed necessary by the Surveyor, a suitable non-destructive examination may be required.

Table 5.4.2.1 : Survey preparation

Special Survey No. I Age ≤ 5	Special Survey No. II 5 < Age ≤ 10	Special Survey No. III 10 < Age ≤ 15	Special Survey No. IV and subsequently Age > 15
1) All tanks, peaks, bilges and drain wells, engine and boiler spaces and other spaces are to be cleared out and cleaned as necessary for examination. Floor plates in engine and boiler spaces are to be lifted as may be necessary for examination of the structure underneath. Where necessary ceiling, lining, casings and loose insulation are to be removed as required by the Surveyor for examination of the structure. Compositions on the plating are to be examined and sounded, but need not be disturbed if found satisfactorily adhering to the plating 2) The steelwork is to be exposed and cleaned as may be required for its proper examination by the Surveyor and close attention is to be paid to the parts of the structure which are particularly liable to excessive corrosion or to deterioration due to other causes. 3) All tanks are to be cleaned as necessary to permit examination. 4) Casings or covers of air, sounding, steam and other pipes, spar ceiling and lining in way of the side scuttles are to be removed, as required by the Surveyor.	1) Requirements of Special Survey I to be complied with 2) The chain locker is to be cleaned internally. The chain cables are to be ranged for inspection. The anchors are to be cleaned and placed in an accessible position for inspection.	1) Requirements of Special Survey II to be complied with 2) Portions of wood sheathing, or other covering, on steel decks are to be removed, as considered necessary by the Surveyor, in order to ascertain the condition of the plating.	1) Requirements of Special survey III to be complied with

Table 5.4.3.2 : Requirements for internal examination of tanks

Tank	Special Survey No. I Age ≤ 5	Special Survey No. II 5 < Age ≤ 10	Special Survey No. III 10 < Age ≤ 15	Special Survey No. IV and subsequent Age > 15
Fuel oil bunker tanks - Engine room - Other area	 None None	 None One	 One Two	 One Half the number of tanks, minimum 2
Lub.oil	None	None	None	One
Fresh water	None	One	All	All

Notes:

1) These requirements apply to tanks of integral (structural) type.

2) If a selection of tanks is accepted to be examined, then different tanks are to be examined at each special survey, on a rotational basis.

3) Peak tanks (all uses) are subject to internal examination at each special survey.

4) At special surveys No.III and subsequent special surveys one deep tank for fuel oil is to be included, if fitted.

5.4.3.4 Where ballast tanks have been converted to void spaces, the survey extent is to be based upon ballast tank requirements.

5.4.3.5 For ballast tanks, excluding double bottom tanks, where a hard protective coating is found in POOR condition and it is not renewed, where soft or semi-hard coating has been applied, or where a protective coating was not applied from the time of construction, the space in question is to be internally examined at Annual Surveys. Thickness measurement is to be carried out as deemed necessary by the Surveyor.

5.4.3.6 For double bottom ballast tanks where a protective coating is found in POOR condition and it has not been renewed or where soft or semi-hard coating has been applied, or where a protective coating was not applied from the time of construction, the spaces in question may be examined at Annual Surveys. When considered necessary by the Surveyor, thickness measurement is to be carried out.

5.4.3.7 All watertight bulkheads and watertight doors are to be examined. All decks, casings and superstructures are to be examined. Attention is to be given to the corners of openings and other discontinuities in way of the strength decks and top sides.

5.4.3.8 The masts, standing rigging and anchors are to be examined.

The Surveyor should satisfy himself that there are sufficient mooring ropes on board and also that a tow line is provided when this is a Rule requirement.

5.4.3.9 The steering gear, and its connections and control systems (main and alternative) are to be examined. The auxiliary steering gear with its various parts are to be examined in working condition.

5.4.3.10 The hand pumps and suctions, air and sounding pipes are to be examined. The Surveyors are to ensure that striking plates are fitted under the sounding pipes whilst examining the tanks internally.

Automatic air pipe heads are to be internally examined at special surveys as indicated in Table 5.4.3.10. For designs where the inner parts cannot be properly inspected from outside, the head is to be removed from the air pipe. Particular attention is to be paid to the condition of the zinc coating in heads constructed from galvanised steel.

5.4.3.11 The Surveyor should satisfy himself regarding the efficient condition of the following :

- Means of escape from machinery spaces, crew and passenger spaces and spaces in which crew are normally employed;

- Means of communication between bridge and engine room and between bridge and alternative steering position;

- Helm indicator;

- Protection to the aft steering wheel and the gear.

5.4.3.12 The chain cables are to be ranged and the anchors and the chain cables are to be examined. At special survey no. II and subsequent special surveys, the chain cables are to be gauged. Any length of chain cable which is found to have reduced in mean diameter at its most worn part by more than 12 per cent of its original rule diameter is to be renewed.

Table 5.4.3.10 : Requirements for internal examination of automatic air pipe heads

Location	**Special survey No.I Age ≤ 5**	**Special survey No.II 5 < Age ≤ 10**	**Special survey No.III and subsequent Age > 10**
forward 0.25L	Two air pipe heads[1,2] one port and one starboard on exposed decks	All air pipe heads on exposed decks	All air pipe heads[3] on exposed decks
aft of 0.25L from the forward perpendicular	Two air pipe heads[1,2] one port and one starboard on exposed decks	At least 20% of air pipe heads[1,2] on exposed decks	

Notes:

1. Preferably air pipes serving ballast tanks.
2. The selection of air pipe heads is to be made by the attending Surveyor. According to the results of the inspection, the Surveyor may require additional air pipe heads to be examined.
3. When there is substantiated evidence of replacement within the previous five years, individual air pipe heads may not be examined.

5.4.3.13 The windlass is to be examined.

5.4.3.14 The chain locker, hold fasts, hawse pipes and chain stoppers are to be examined and pumping arrangements of the chain locker tested.

5.4.3.15 A thorough examination of aft and forward emergency towing arrangements is to be carried out to ensure its ready availability and satisfactory condition.

- examination of pick-up gear, towing pennant and chafing gear for possible deterioration;
- examination of strong points, fairleads, pedestal roller and their attachment to hull structure.

The survey is to confirm that one of the towing arrangements (aft or forward) are pre-rigged.

5.4.3.16 For vessels with single point mooring arrangements where 'SPM' notation is assigned, the following is to be carried out:

a) A thorough examination of the components of the single point mooring system (bow chain stoppers, bow fairleads, pedestal roller fairleads, winches and capstans) to verify their satisfactory condition.

b) A close-up examination of the hull structures supporting and adjacent to the components of the single point mooring system to verify that there is no deformation or fracture. Thickness determination and non-destructive tests are to be carried out if required by the Surveyor.

5.4.3.17 Engine room structure is to be examined. Particular attention being given to tank tops, shell plating in way of tank tops, brackets connecting side shell frames and tank tops and engine room bulkheads in way of tank tops and bilge wells. Where excessive areas of wastage are found, thickness measurements are to be carried out and renewals or repairs made when wastage exceeds allowable limits.

5.4.3.18 Boundaries of double bottom, deep, ballast, peak and other tanks are to be tested with a head of liquid to the top of air pipes. Boundaries of fuel oil, lub.oil and fresh water tanks are to be tested with a head of liquid to the highest point that liquid will rise under service conditions. Tank testing of fuel oil, lub.oil and fresh water tanks may be specially considered based on a satisfactory external examination of the tank boundaries and a confirmation from the Master stating that the pressure testing has been carried out according to the requirement with satisfactory results.

5.4.3.19 The loading instrument is to be checked for accuracy by applying test load conditions in presence of the Surveyor.

5.4.3.20 Examination of accommodation ladders, gangways and their winches are to be carried out as required for annual surveys. In addition, the accommodation ladders and gangways are to be operationally, tested with the specified maximum operation load.

The tests are to be carried out with the load applied as uniformly as possible along the length of the accommodation ladder or gangway, at an angle of inclination corresponding to the maximum bending moment on the accommodation ladder or gangway.

Accommodation ladder winch is to be operationally tested at special surveys. The brake system of the winch is to be tested for holding the maximum operational load on the ladder.

For existing installations on board ships constructed prior to 01 Jan 2010 where the maximum operational load is not known, load nominated by the shipowner or operator may be considered as the test load.

5.4.4 Thickness measurement

5.4.4.1 The minimum requirements for thickness measurement are given in Table 5.4.4.1. The surveyor may extend the thickness measurements as deemed necessary.

Table 5.4.4.1 : Table of minimum requirements to thickness measurements of liquefied gas carriers

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequently** **Age > 15**
1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel
2) Within the cargo area : One section of deck plating for the full beam of the ship within 0.5L amidships in way of a ballast tank, if any.	2) Within the cargo area: a) Each deck plate b) One Transverse section within 0.5L amidships in way of a ballast tank, if any	2) Within the cargo area: a) Each deck plate b) Two Transverse sections (1) c) All wind and water strakes	2) Within the cargo area: a) Each deck plate b) Three Transverse sections (1) c) All wind and water strakes d) Each bottom plate e) Duct keel or pipe tunnel plating and internals
3) Measurements of structural members subject to close-up survey according to Table 5.4.5.1, for general assessment and recording of corrosion pattern	3) Measurements of structural members subject to close-up survey according to Table 5.4.5.1, for general assessment and recording of corrosion pattern	3) Measurements of structural members subject to close-up survey according to Table 5.4.5.1, for general assessment and recording of corrosion pattern	3) Measurements of structural members subject to close-up survey according to Table 5.4.5.1, for general assessment and recording of corrosion pattern
	4) Selected wind and water strakes outside the cargo area	4) Selected wind and water strakes outside the cargo area	4) All wind and water strakes outside the cargo area
		5) Internals in forepeak and after peak tanks	5) Internals in forepeak and afterpeak tanks
			6) All exposed main deck plating outside cargo area
			7) Representative exposed superstructure deck plating (poop, bridge, forecastle deck)

Table 5.4.4.1 : (Contd.)			
Special Survey No. I Age ≤ 5	**Special Survey No. II 5 < Age ≤ 10**	**Special Survey No. III 10 < Age ≤ 15**	**Special Survey No. IV and subsequently Age > 15**
			8) All keel plates, additional bottom plates in way of machinery space, aft end of tanks and cofferdams outside cargo area
			9) a) Plating of sea chests. b) Shell plating in way of overboard discharges as considered necessary by the Surveyor.
(1) at least one section is to include a ballast tank within 0.5L amidships, if any.			

Table 5.4.4.2 : Guidance for additional thickness measurements in way of substantial corrosion

Structural Member	Extent of Measurement	Pattern of Measurement
Plating	Suspect area and adjacent plates	5 point pattern over 1 square meter
Stiffeners	Suspect area	3 measurements each in line across web and flange

5.4.4.2 Where thickness measurements indicate substantial corrosion, the number of thickness measurements are to be increased to determine the extent of substantial corrosion. Table 5.4.4.2 may be used as guidance for additional measurements.

5.4.4.3 For areas in tanks where coating are found to be in a GOOD condition, the extent of thickness measurements may be specially considered, by the Surveyor.

5.4.4.4 Transverse sections are to be chosen where the largest reductions are suspected to occur or are revealed from deck plating measurements.

5.4.4.5 The thickness measurements are to be carried out by a qualified firm certified by IRS.

5.4.4.6 In order to ensure necessary control during the process, thickness measurements are normally to be carried out under the supervision of the Surveyor. The Surveyor has the right to re-check the measurements as deemed necessary to ensure acceptable accuracy.

5.4.4.7 A thickness measurement report is to be prepared. The report is to give the location of measurements, the thickness measured as well as corresponding original thickness. Furthermore, the report is to give the date when the measurements were carried out, type of measurement equipment, names of personnel and their qualifications and has to be signed by the operator. The Surveyor is to review the report of the final thickness measurement after repairs have been carried out and countersign the cover page.

5.4.5 Close-up survey requirements

5.4.5.1 The minimum requirements for Close-up Surveys at Special Survey are given in Table 5.4.5.1.

5.4.5.2 The Surveyor may extend the Close-up Survey as deemed necessary taking into account the maintenance of the tanks under survey, the condition of the corrosion prevention system and also in the following cases:

a) In particular, tanks having structural arrangements or details which have suffered defects on similar tanks or on similar ships according to available information.

b) In tanks which have structures approved with reduced scantlings due to an approved corrosion control system.

5.4.5.3 For areas in tanks where hard protective coatings are found to be in a GOOD condition, the extent of Close-up Surveys according to Table 5.4.5.1 may be specially considered by the Surveyor.

Table 5.4.5.1 : Table of minimum requirements for close-up surveys at special surveys of liquefied gas carriers

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **subsequent age > 10**
One web frame in a representative ballast tank of the topside, hopper side and double hull side type (1) One transverse bulkhead in a ballast tank (3)	All web frames in a ballast tank, which is to be a double hull side tank or a topside tank. If such tanks are not fitted, another ballast tank is to be selected (1) One web frame in each remaining ballast tank (1) One transverse bulkhead in each ballast tank (2)	All web frames in all ballast tanks (1) All transverse bulkheads in all ballast tanks (2)

(1) Complete transverse web frame including adjacent structural members.
(2) Transverse bulkhead complete, including girder system and adjacent members and adjacent longitudinal bulkhead structure.
(3) Transverse bulkhead lower part including girder system and adjacent structural members.

Notes :

a) Ballast tanks include topside, double hull side, double bottom, hopper side, or any combined arrangement of the aforementioned and peak tanks where fitted.

b) For ships having independent tanks of type C, with a midship section similar to that of a general cargo ship, the extent of close-up surveys may be specially considered by the Surveyor.

5.4.6 Cargo containment and systems

5.4.6.1 All cargo tanks are to be examined internally, also externally so far as is practicable, particular attention being paid to the plating in way of supports of securing arrangements, tower structures, seatings and pipe connections. Attention is also to be paid to the sealing arrangements in way of the deck penetrations and the antiflotation arrangements for independent tanks. The tightness of all cargo tanks is to be verified by an appropriate procedure. The ships gas detection equipment may be used for tightness test of independent tanks below deck. Provided that the structural examination is satisfactory, that the gas leakage monitoring systems have been found to be operating satisfactorily and that the voyage records have not shown any abnormal operation, cargo tanks do not require to be hydraulically tested.

5.4.6.2 Non-destructive testing is to supplement cargo tank inspection with special attention to be given to the integrity of the main structural members, tank shell and highly stressed parts, including welded connections as deemed necessary by the Surveyor. However, for Type C independent tanks non-destructive testing can not be dispensed with totally. The following items are, inter alia, considered as highly stressed parts:

- Cargo tank supports and anti-rolling/anti-pitching devices.

- Web frames or stiffening rings.

- Swash bulkhead boundaries.

- Dome and stump connections to tank shell.

- Foundations for pumps, towers, ladders etc.

- Pipe connections.

- Y-connections between tank shell and a longitudinal bulkhead of bilobe tanks.

5.4.6.3 For independent tanks of type B, the extent of non-destructive testing is to be given in a programme specially prepared for cargo tank design.

5.4.6.4 If findings of 5.4.6.1 to 5.4.6.2 or examination of voyage records do not reveal a satisfactory structural integrity of the cargo tanks, a hydraulic or hydro-pneumatic test is to be carried out. For integral tanks and for independent tanks of type A and B, the test pressure is to be atleast equal to MARVS. It is to be ensured that the maximum primary membrane stress or maximum bending stress in a primary membrane under the test conditions does not exceed 90% of the yield strength of the material (as fabricated) at the test temperature.

5.4.6.5 At every other special survey (i.e. 2nd, 4th, 6th etc.) independent cargo tanks of type C are to be either:

- hydraulically or hydro-pneumatically tested to 1.25 MARVS followed by non-destructive testing in accordance with para 5.4.6.2;

OR

- subjected to a thorough planned non-destructive testing. The testing programme is to be specially prepared for the tank design. Alternatively the items detailed in para 5.4.6.2 are to be subjected to non-destructive testing. The extent of radiographic examination with insulation removed as necessary is to be atleast 10% of the welded connections in each of the above mentioned areas, internally and externally as applicable.

5.4.6.6 Deck mounted cargo storage tanks are to be examined in the same manner as main cargo tanks.

5.4.6.7 Secondary barriers are to be examined for their effectiveness, visually whenever possible, or by means of pressure/vacuum tests on the inter-barrier spaces over a period of 36 hours. Alternative means of checking the secondary barriers will be considered. For membrane and semi-membrane tank systems, inspection and testing are to be carried out in accordance with programmes specially prepared in accordance with an approved method for the actual tank system.

For membrane containment systems, a tightness test of the primary and secondary barrier is to be carried out in accordance with the system designers procedures and acceptance criteria as approved by IRS. Low differential pressure may be used for monitoring the cargo containment system performance, however, is not considered an acceptable test for the tightness of the secondary barrier.

For membrane containment systems with glued secondary barriers if the designer’s threshold values are exceeded, an investigation is to be carried out and additional testing such as thermographic or acoustic emissions testing is to be carried out.

5.4.6.8 Where cargo containment systems have secondary barriers which cannot be examined or tested and have been approved on the basis of extensive prototype testing, the barriers will be considered to remain efficient provided a cold spot examination of the adjacent steel work is satisfactory and records of the steel work temperature readings are verified as acceptable.

5.4.6.9 Where a cargo tank or the hull structure is insulated and the insulation is accessible, the insulation should be examined externally, together with any vapour or protective barrier, and sections removed for examination, if considered necessary by the Surveyor. Special attention should be given to insulation in way of chocks, supports and keys. Portions of the insulation are also to be removed, if required by the Surveyor, to enable the condition of the plating to be ascertained. Where the insulation is not accessible, see 5.2.8.2.

5.4.6.10 Cargo tank internal pipes and fittings are to be examined, and all valves and cocks in direct communication with the interiors of the tanks are to be opened out for inspection and the connection pipes are to be examined internally, so far as is practicable.

5.4.6.11 Pressure relief valves and vacuum relief valves on cargo tanks and inter-barrier spaces are to be opened out for inspection. Pressure relief valves are subsequently to be adjusted to lift at a pressure in accordance with 5.3.3d). Relief valve harbour settings are to be checked, if applicable. Valves may be removed from the shell for the purpose of making this adjustment under pressure of air or other suitable gas. Relief valves on cargo gas and liquid pipelines are to have their pressure settings checked. The valves may be removed from the pipelines for the purpose.

If the cargo tanks are equipped with relief valves with non-metallic membranes in the main or pilot valves, then such non-metallic membranes are to be replaced. If a proper record of continuous overhaul and retesting of individually identifiable relief valves is maintained, then consideration will be given to acceptance on the basis of opening, internal examination and testing of a representative sampling of valves, including each size and type of liquefied gas or vapour relief valve in use, provided there is a logbook evidence that the remaining valves have been overhauled and tested since crediting of the previous special survey.

5.4.6.12 All cargo pumps, cargo booster pumps and cargo vapour pumps are to be opened out for examination. If requested by the Owner, these items may be examined on a Continuous Survey basis provided the interval between examination of each item does not exceed five years. Pumping systems for inter-barrier spaces are to be checked and verified to be in good working order.

5.4.6.13 Where considered necessary, insulated cargo gas and liquid pipelines are to have sections of insulation removed to ascertain the condition of the pipes. If visual examination raises doubt as to the integrity of the pipe lines, then the pipe lines are to be pressure tested to 1.25 times MARVS. Care is to be taken that in the replacement of insulation the outer vapour seal is made good.

5.4.6.14 Equipment for the production of inert gas is to be examined and shown to be operating satisfactorily within the gas specification limits. Pipelines, valves, etc., for the distribution of the inert gas are to be generally examined. Pressure vessels for the storage of inert gas are to be examined internally and externally and the securing arrangements are to be specially examined. Pressure relief valves are to be demonstrated to be in good working order. Liquid nitrogen storage vessels are to be examined, so far as is practicable, and all control equipment, alarms and safety devices are to be verified as operational.

5.4.6.15 Gas tight bulkhead shaft seals are to be opened out so that the sealing arrangements may be checked.

5.4.6.16 Sea connections associated with the cargo handling equipment are to be opened out when the ship is in dry-dock.

5.4.6.17 The arrangements for discharging the cargo overboard in an emergency are to be checked.

5.4.6.18 Special Survey I (Ships five years old)-reliquefaction / refrigeration equipment

a) Each reciprocating compressor is to be opened out. Cylinder bores, pistons, piston rods, connecting rods, valves and seats, glands, relief devices, suction filters and lubricating arrangements are to be examined. Crankshafts are to be examined but crankcase glands and the lower half of main bearings need not be exposed if the Surveyor is satisfied with the alignment and wear.

b) Where other than reciprocating type compressors are fitted, or where there is a program of replacement instead of surveys on board, alternative survey arrangements will be considered. Each case will be given individual consideration.

c) The water end covers of condensers are to be removed for examination of the tubes, tube plates and covers.

d) Refrigerant condenser cooling water pumps, including standby pump(s) which may be used on other services, are to be opened out for examination.

e) Where a pressure vessel is insulated, sufficient insulation is to be removed, especially in way of connections and supports, to enable the vessel's condition to be ascertained.

f) Insulated pipes are to have sufficient insulation removed to enable their condition to be ascertained. Vapour seals are to be specially examined for condition.

g) The Surveyor is to satisfy himself that all pressure relief valves and/or safety discs throughout the system are in good order. No attempt, however, is to be made to test primary refrigerant pressure relief valves on board ship.

h) The items covered by (a) to (d) may, at the request of the Owner, be examined on a Continuous Survey basis provided the interval between examination of each item does not exceed five years.

5.4.6.19 Special Survey I (ships five years old)- Methane burning equipment

a) Where methane is used as fuel for main propulsion purposes, the associated compressors and heat exchangers are to be opened out and examined as for reliquefaction/refrigeration equipment. The steam side of steam heaters is to be hydraulically tested to 1.5 times the design pressure.

b) Methane gas pipe trunks or casings are to be generally examined and the exhaust or inerting arrangements for these trunks are to be verified.

c) All alarms associated with the methane burning systems are to be verified.

5.4.6.20 Special Survey II and Special Surveys thereafter (ships 10 years old and over)

a) The requirements of 5.4.6.1 to 5.4.6.19 are to be complied with.

b) Water cooled condensers in which the primary refrigerant is in contact with the shell are to have the end covers removed and the shell pneumatically tested to a pressure equal to the designed working pressure.

c) All other pressure vessels in the reliquefaction/refrigeration system, methane burning system and other handling systems are to be pneumatically tested to a pressure equal to the designed working pressure.

d) Liquid cargo pipes are to be tested by approved means, to a pressure equal to 1.25 times the working pressure. Alternatively, selected representative lengths may be removed for internal examination and hydraulic testing.

e) At Special Survey III and at each alternate Special Survey thereafter, plating of independent cargo tanks, and also the hull structural plating surrounding cargo tanks, where it is insulated on one side, is to be measured for thickness by a non-destructive method.

5.5 Special Surveys - Machinery

5.5.1 Requirements for examination of machinery and systems are given in Sec.8.

Section 6

Surveys - Other Ship Types

6.1 Scope

6.1.1 This section gives the requirements for periodical surveys of all ship types other than bulk carriers, oil tankers, chemical tankers and liquefied gas carriers which are covered in Sections 2 to 5 of this chapter. The requirements for general dry cargo ships defined in 1.2.17, are also included.

6.2 Annual surveys

6.2.1 General

6.2.1.1 Annual Surveys are to be carried out within 3 months before or after the anniversary date each year. These should be held concurrently with statutory annual or other relevant statutory Surveys, where practicable.

6.2.1.2 At Annual Surveys, the Surveyor is to examine the hull and machinery, so far as necessary and practicable, in order to be satisfied as to their general condition.

6.2.1.3 It is to be confirmed that no new installation of material containing asbestos was carried out since last survey.

6.2.2 Hull - General

6.2.2.1 The survey is to consist of an examination for the purpose of ensuring, as far as practicable, that the hull, equipment, hatch coamings, hatch covers including their securing arrangement, other closing appliances and related piping are maintained in satisfactory/efficient condition.

a) Weather deck, shipside plating above water line.

b) Hatchways on freeboard and superstructure decks; exposed casings; skylights and fiddley openings; deck houses; companionways and superstructure bulkheads; side, bow and stern doors; side scuttles and dead lights; flush deck scuttles; ash shoots and other openings.

c) Weld connection between air pipes and deck plating, air pipe heads on exposed decks (external examination), flame screens on vents to all bunker tanks; ventilators and closing devices.

d) Scuppers and sanitary discharges as far as practicable together with valves and their controls.

e) Guard rails, bulwarks, freeing ports, gangways, walkways and life lines, fittings and appliances for timber deck cargo.

f) Watertight bulkheads and their penetrations as far as practicable.

6.2.2.2 Cargo hatch covers and coamings are to be examined to ensure that no alterations have been made to the approved arrangements :

a) Mechanically operated hatch covers are to be examined for satisfactory condition of:

- hatch covers;
- tightness devices of longitudinal, transverse and intermediate cross junctions, gaskets, gasket lips, compression bars, drainage channels;
- clamping devices, retaining bars, cleating;
- chain or rope pulleys;
- guides;
- guide rails and track wheels;
- stoppers, etc.;
- wires, chains, gypsies, tensioning devices;
- hydraulic system essential to closing and securing;
- safety locks and retaining devices.

b) Cargo hatch covers of the portable type (i.e. wood or steel pontoons) are to be examined to confirm the satisfactory condition of:

- wooden covers and portable beams, carriers or sockets for the portable beams and their securing devices;
- steel pontoons;
- tarpaulins;
- cleats, battens and wedges;
- hatch securing bars and their securing devices;
- loading pads/bars and the side plate edge;
- guide plates and chocks;
- compression bars, drainage channels and drain pipes, if any.

c) Checking the satisfactory condition of hatch coamings plating and their stiffeners.

d) Random checking of the satisfactory operation of mechanically operated hatch covers :

- stowage and securing in open position;
- proper fit, locking and efficiency of sealing in closed condition;
- operational testing of hydraulic and power components, wires, chains and link drives.

In the case of hatch covers / steel pontoons of general dry cargo ships, a close-up survey of hatch cover plating is to be carried out.

6.2.2.3 All watertight doors in watertight bulkheads, to be examined and tested (locally and remotely) as far as practicable.

6.2.2.4 Anchoring and mooring equipment is to be examined as far as is practicable.

6.2.2.5 Where applicable Surveyor should satisfy himself regarding the freeboard marks on the ship's side.

6.2.2.6 Suspect areas identified at previous special or intermediate surveys are to be close-up surveyed. Thickness measurements are to be taken in the area of substantial corrosion identified at previous surveys.

6.2.2.7 Examination of Ballast Tanks when required as a consequence of the results of the

Special Survey or Intermediate Survey (See 6.4.3.1, 6.4.3.2 and 6.3.2, 6.3.3 respectively). When extensive corrosion is found, thickness measurement is to be carried out. If the results of these thickness measurements indicate substantial corrosion then the extent of thickness measurements are to be increased to determine the extent of areas of substantial corrosion in accordance with Table 6.4.8.2.

6.2.2.8 The Surveyor is to confirm that, where required, an approved loading instrument together with its operation manual are available on board, (See Pt.3, Ch.5). It is to be verified by the Surveyor that the loading instrument is checked for accuracy at regular intervals by the ship's staff by applying test loading conditions.

6.2.2.9 Accommodation ladders are to be examined at annual surveys. Satisfactory condition of the following items is to be checked, in particular :

a) steps;
b) platforms;
c) all support points such as pivots, rollers, etc.;
d) all suspension points such as lugs, brackets, etc.;
e) stanchions, rigid handrails, hand ropes and turntables;
f) davit structure, wire and sheaves, etc.

6.2.2.10 Gangways are to be examined at annual surveys. Satisfactory condition of the following items is to be checked, in particular :

a) treads;
b) side stringers, cross-members, decking, deck plates, etc.;
c) all support points such as wheel, roller, etc.;
d) stanchions, rigid handrails, hand ropes.

6.2.2.11 Winches of accommodation ladders and gangways are to be examined to verify the satisfactory condition of the following items:

a) brake mechanism including condition of brake pads and band brake, if fitted;
b) remote control system, and
c) power supply system for electric motor.

6.2.2.12 Davits and fittings on the ship’s deck associated with accommodation ladders and gangways are to be examined for satisfactory condition at annual surveys. Fittings or structures for means of access to deck such as handholds in a gateway or bulwark ladder and stanchions are also to be examined.

6.2.2.13 The maintenance and inspection records of accommodation ladders and gangways are to be verified. It is to be confirmed that supporting wires are being renewed at intervals not exceeding 5 years.

6.2.2.14 When examining internal spaces, as far as practicable, the permanent means of access where appropriate, are to be verified that they remain in good condition.

6.2.2.15 For vessels subject to IMO PSPC (See Pt.3, Ch.2, 3.6) it is to be confirmed that the maintenance, repair and partial re-coating of dedicated ballast tanks, as appropriate, are recorded in the coating technical file.

6.2.3 Examination of cargo holds of general dry cargo ships.

6.2.3.1 For cargo ships of 10 – 15 years of age:

a) Overall survey of one forward and one after cargo hold and their associated tween deck spaces.

b) When considered necessary by the Surveyor or where extensive corrosion exists, thickness measurement is to be carried out. If the results of these thickness measurements indicate substantial corrosion, then the extent of thickness measurements is to be increased to determine the extent of areas of substantial corrosion in accordance with Table 6.4.8.2.

6.2.3.2 For cargo ships over 15 years of age:

a) Overall survey of all cargo holds and tween deck spaces.

b) In a forward lower cargo hold and one other selected lower cargo hold:

   - Close-up examination of sufficient extent, minimum 25% of frames, to establish the condition of the lower region of the shell frames including approx. lower one third length of side frame at side shell, side frame end attachment and the adjacent shell plating.

   - Where this level of survey reveals the need for remedial measures, the survey is to be extended to include a close-up survey of all of the shell frames and adjacent shell plating of those cargo holds and associated tween deck spaces (as applicable) as well as a close-up survey of sufficient extent of all remaining cargo holds and tween deck spaces (as applicable).

c) When considered necessary by the surveyor, or where extensive corrosion exists, thickness measurement is to be carried out. If the results of these thickness measurements indicate substantial corrosion, then the number of thickness measurements are to be increased to determine the extent of substantial corrosion in accordance with Table 6.4.8.2.

d) Where the protective coating in cargo holds, as applicable, is found to be in a GOOD condition, the extent of close-up surveys may be specially considered.

e) All piping and penetrations in cargo holds, including overboard piping are to be examined.

6.2.4 Machinery and systems

6.2.4.1 A general examination of the machinery, boilers, all pressurised systems (steam, pneumatic, hydraulic) and their associated fittings, propulsion system and auxiliary machinery to see whether they are being properly maintained and with particular attention to the fire and explosion hazards.

6.2.4.2 Confirmation that machinery, boilers and other pressure vessels, associated piping systems and fittings are so installed and protected as to reduce to a minimum any danger to persons on board, due regard being given to moving parts, hot surfaces and other hazards.

6.2.4.3 Confirmation that Periodical Surveys of boilers and other pressure vessels have been carried out as required by the Rules and the safety devices have been tested.

6.2.4.4 Confirmation that the normal operation of the propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative.

6.2.4.5 Confirmation that means are provided so that machinery can be brought into operation from the dead ship condition without external aid.

6.2.4.6 All main and auxiliary steering arrangements and their associated equipment and control systems are to be examined and tested. Where applicable, Surveyors are to verify that log entries have been made in accordance with statutory requirements.

6.2.4.7 Steering chains are to be cleaned for ascertaining wear and tear and lengths of chain worn in mean diameter by more than 12 per cent of the original rule diameter are to be renewed.

6.2.4.8 All the means of communication between the navigating bridge and the machinery control positions, as well as the bridge and the main alternative steering position, if fitted, are to be tested. It is to be confirmed that means of indicating the angular position of the rudder are operating satisfactorily.

6.2.4.9 Confirmation that with ships having emergency steering positions there are means of relaying heading information and, when appropriate, supplying visual compass readings to the emergency steering positions.

6.2.4.10 Confirmation that various alarms required for hydraulic power operated, electric and electro-hydraulic steering gears are, operating satisfactorily and that the recharging arrangements for hydraulic power operated steering gears are being maintained.

6.2.4.11 Examining the means for the operation of the main and auxiliary machinery essential for propulsion and the safety of the ship, including when applicable, the means of remotely controlling the propulsion machinery from the navigating bridge and the arrangements to operate the main and other machinery from a machinery control room.

6.2.4.12 Confirmation that the engine room telegraph, the second means of communication between the navigation bridge and the machinery space and the means of communication with any other positions from which the engines are controlled are operating satisfactorily.

6.2.4.13 Confirmation that the engineer's alarm is clearly audible in the engineer's accommodation.

6.2.4.14 The bilge pumping systems and bilge wells including operation of each bilge pump, extended spindles and level alarms, where fitted, are to be examined as far as is practicable. It is also to be confirmed that bilge pumping system for each watertight compartment is satisfactory.

It is also to be confirmed that drainage from enclosed cargo spaces situated on freeboard deck is satisfactory.

6.2.4.15 Examining visually the condition of any expansion joints in sea water system.

6.2.4.16 General examination visually and in operation, as feasible, of the main electrical machinery, the emergency sources of electrical power, the switch gear, other electrical equipment including the lighting system is to be carried out.

6.2.4.17 Confirmation as far as practicable, the operation of the emergency source(s) of electrical power, including their starting arrangement, the systems supplied, and when appropriate, their automatic operation.

6.2.4.18 Examining in general, that the precautions provided against shock, fire and other hazards of electrical origin are being maintained.

6.2.4.19 General Examination of automation equipment is to be carried out. Satisfactory operation of safety devices, bilge level detection and alarm systems and control systems is to be verified.

6.2.4.20 For single hold cargo ships which require fitment of hold water level detectors as per Pt.4, Ch.3, Sec.3.6, the annual survey is to include an examination and a test of the water ingress detection system and their alarms.

6.2.4.21 Confirmation that machinery space ventilation systems are in good working condition.

6.2.5 Fire protection, detection and extinction

6.2.5.1 The arrangements for fire protection, detection and extinction are to be examined and are to include confirmation that no changes have been made in the structural fire protection. Following are to be examined / verified:

a) verification that fire control plans are properly posted;

b) examination as far as possible and testing as feasible of the fire and/or smoke detection system(s);

c) examination of the fire main system and verification that each fire pump including the emergency fire pump can be operated separately so that the two required powerful jets of water can be produced simultaneously from different hydrants;

d) verification that fire hoses, nozzles, applicators and spanners are in good working condition and situated at their respective locations;

e) examination of fixed fire fighting system controls, piping, instructions and marking, checking for evidence of proper maintenance and servicing including date of last systems tests;

f) verification that all semi-portable and portable fire extinguishers are in their stowed positions, checking for evidence of proper maintenance and servicing, conducting random check for evidence of discharged containers;

g) verification, as far as practicable, that the remote controls for stopping fans and machinery and shutting off fuel supplies in machinery spaces are in working order;

h) examination of the closing arrangements of ventilators, funnel annular spaces, skylights, doorways and tunnel, where applicable;

i) confirmation that the fire fighters' outfits and emergency escape breathing devices (EEBDs) are complete and in good condition and that the cylinders, including the spare cylinders, of any required self-contained breathing apparatus are suitably charged;

j) examination of any manual and automatic fire doors and proving their operations;

k) examination of the fire-extinguishing systems for spaces containing paint and/or flammable liquids and deep fat cooking equipment in accommodation and service spaces;

l) examination of the fire safety requirements of any helicopter facilities;

m) examination of the fire protection arrangement in cargo, vehicle and ro-ro spaces and confirmation, as far as practicable and as appropriate, the operation of the means of control provided for closing the various openings;

n) Examination, when appropriate, of the special arrangements for carrying dangerous goods, including checking the electrical equipment and wiring, the ventilation, protective clothing and portable appliances and testing of water supply, bilge pumping and any water spray system.

Surveys carried out by the National Authority of the country in which the ship is registered would normally be accepted as meeting these requirements, at the discretion of the Surveyor.

6.2.5.2 Confirmation that the means of escape from accommodation, machinery spaces and other spaces are satisfactory.

6.2.5.3 Examination of the arrangements for gaseous fuel for domestic purposes.

6.2.6 Shell and inner doors of ro-ro ships

6.2.6.1 The survey is to consist of an examination to verify, as far as is practicable, that the bow, inner, side shell and stern doors are maintained in a satisfactory condition.

6.2.6.2 Confirmation is to be obtained that no unapproved changes have been made to the bow, inner, side shell and stern doors since the last survey.

6.2.6.3 Documents

If an Operating and Maintenance Manual (OMM) is required, it is to be verified that a copy approved by IRS is on board and any possible modifications are included. It is to be verified that documented operating procedures for closing and securing doors are kept on board and posted at an appropriate place. The OMM is to be examined with special attention to the register of inspections and its contents as a basis for the survey.

6.2.6.4 Structural examination

Bow, inner, side shell and stern doors are to be examined with particular attention paid to:

- Structural arrangement of doors including plating, secondary stiffeners, primary structure, hinging arms and welding;

- Shell structure surrounding the opening of the doors and the securing, supporting and locking devices (refer Pt.3, Ch.12, Sections 5 and 6) including shell plating, secondary stiffeners, primary structure and welding;

- Hinges and bearings, thrust bearings;

- Hull and door side supports for securing, supporting and locking devices;

- Close-up survey of securing, supporting and locking devices including welding, refer to Table 6.2.6.4 for minimum requirements.

Whenever a crack is found, an examination with NDT is to be carried out in the surrounding areas and for similar items as considered necessary by the Surveyor.

6.2.6.5 Measurement of clearances

Clearances of hinges, bearings and thrust bearings are to be taken, where no dismantling is required. Where the function test is not satisfactory, dismantling may be required to measure the clearances. If dismantling is carried out, a visual examination of hinge pins and bearings together with NDT of the hinge pin is to be carried out. Clearances of securing, supporting and locking devices are to be measured, where indicated in the OMM

Table 6.2.6.4 : Minimum requirements for close-up surveys of doors, locking, securing and supporting devices and fittings	
List of the devices and fittings and associated welding to be subject to close-up survey by the attending Surveyor:	
i)	Cylinder securing pins, supporting brackets, back-up brackets (where fitted) and their welding connections;
ii)	Hinge pins, supporting brackets, back-up brackets (where fitted) and their welded connections;
iii)	Locking hooks, securing pins, supporting brackets, back-up brackets (where fitted) and their welded connections;
iv)	Locking pins, supporting brackets, back-up brackets (where fitted) and their welded connections;
v)	Locating and stopper devices and their welded connections.

6.2.6.6 Sealing arrangement

An examination of packing material / rubber gaskets and retaining bars or channels, including welding is to be carried out.

6.2.6.7 Drainage arrangement

An examination of drainage arrangement, including bilge wells and drain pipes is to be carried out.

6.2.6.8 Function test of doors

Checking of the satisfactory operation of the bow, inner, side shell and stern doors during a complete opening and closing operation is to be carried out, as applicable, including:

- Proper working of the hinging arms and hinges;
- Proper engagement of the thrust bearings;
- Device for locking the door in the open position;
- Securing, supporting and locking devices;
- Proper sequence of the interlock system for the opening / closing system and the securing and locking devices;
- Mechanical lock of the securing devices;
- Proper locking of hydraulic securing devices in the event of a loss of the hydraulic fluid, according to the procedure provided by the OMM;
- Correct indication of open / closed position of doors and securing / locking devices at navigation bridge and other control stations;
- Isolating of the hydraulic securing / locking devices from other hydraulic systems;
- Confirmation that the operating panels are inaccessible to unauthorized persons;
- Verification that a notice plate giving instructions to the effect that all securing devices are to be closed and locked before leaving harbour is placed at each operating panel and supplemented by warning indicator lights;
- Examination of electrical equipment for opening, closing and securing the doors.

6.2.6.9 Function test of the indicator system

Checking of the satisfactory operation of the indicator system, where fitted, is to be carried out, as applicable, including:

- Proper visible indication and audible alarm on the navigation bridge panel, according to the selected function “harbour / sea voyage” and on the operating panel;
- Lamp test function on both panels;
- Verification that it is not possible to turn off the indicator light on both panels;
- Verification of fail safe performance, according to the procedure provided by the OMM;
- Confirmation that power supply for indicator system is supplied by the emergency source or other secure power supply and independent of the power supply for operating the doors;
- Verification of proper condition of sensors and protection from water, ice formation and mechanical damage.

6.2.6.10 Test of water leakage detection system (where fitted)

The water leakage detection system is to be tested including proper audible alarm on the navigation bridge panel and on the engine control room panel, according to the procedure provided by the OMM.

6.2.6.11 Test of television surveillance system (where fitted)

The television surveillance system is to be tested including proper indication on the navigation bridge monitor and on the engine control room monitor.

6.2.6.12 Tightness test

A hose test or equivalent is to be carried out. If the visual examination and function test have shown satisfactory results, the tightness test of shell doors on ro-ro cargo ships need not be carried out unless considered necessary by the attending surveyor.

6.2.6.13 NDT and thickness measurements

When considered necessary by the Surveyor, NDT and thickness measurements may be required after visual examination and function test.

6.3 Intermediate surveys

6.3.1 General

6.3.1.1 Intermediate surveys are to be carried out at or between the second or third Annual Survey.

Those items which are additional to the requirements of annual survey may be examined at or between the second and third annual survey.

6.3.1.2 The following requirements are applicable for vessels over five years of age.

For vessels below 5 years of age additional examination over and above the requirements of Annual survey may be required at the discretion of the Surveyors.

6.3.1.3 Prior to the commencement of any part of the intermediate survey, a survey planning meeting is to be held between the attending Surveyor(s), the owner's representative in attendance and where involved, the thickness measurement company representative and the master of ship or an appropriately qualified representative appointed by the master or Company for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

6.3.1.4 Concurrent crediting to both Intermediate survey and Special survey for surveys and thickness measurements of spaces is not acceptable.

6.3.2 Vessels of age between 5 and 10 years

6.3.2.1 Ballast tanks

a) An internal general examination of representative ballast tanks is to be carried out as required by (c) and (d). When extensive corrosion is found, thickness measurements are to be carried out. If such examination reveals no visible structural defects, the examination may be limited to a verification that the corrosion prevention system remain efficient.

b) Where POOR coating condition, corrosion or other defects are found in ballast spaces or where hard protective coating was not applied from the time of construction, the examination is to be extended to other ballast spaces of the same type.

c) For ballast tanks, other than double bottom tanks, where a protective coating is found to be in POOR condition and is not renewed, where a soft or semi-hard coating has been applied or where a hard protective coating was not applied from the time of construction, the tank(s) in question are to be examined at subsequent annual surveys.

d) For double bottom ballast tanks, where a protective coating is found to be in POOR condition and is not renewed, where a soft or semi-hard coating has been applied or where a hard protective coating was not applied from the time of construction, the tank(s) in question may be examined at subsequent Annual surveys.

6.3.2.2 Cargo hold of general dry cargo ships

a) An overall survey of one forward and one after cargo hold and their associated tween deck spaces.

b) Areas found suspect at previous surveys are to be surveyed in accordance with 6.2.2.6.

6.3.3 Vessels of age between 10 and 15 years

6.3.3.1 Ballast tanks:

a) An overall survey of all ballast tanks is to be carried out. When extensive corrosion is found, thickness measurements are to be carried out. If such examination reveals no visible structural defects, the examination may be limited to a verification that the corrosion prevention system remain efficient.

b) For ballast tanks, other than double bottom tanks, where a protective coating is found to be in POOR condition and is not renewed, where a soft or semi-hard coating has been applied or where a hard protective coating was not applied from the time of construction, the tank(s) in question are to be examined at subsequent annual surveys.

c) For double bottom ballast tanks, where a protective coating is found to be in POOR condition and is not renewed, where a soft or semi-hard coating has been applied or where a hard protective coating was not applied from the time of construction, the tank(s) in question may be examined at subsequent Annual surveys.

6.3.3.2 Cargo holds of general dry cargo ships:

a) An overall survey of all cargo holds and tween deck spaces.

b) Areas found suspect at previous surveys are to be surveyed in accordance with 6.2.2.6.

c) When considered necessary by the Surveyor or where extensive corrosion exists, thickness measurement is to be carried out. If the results of these thickness measurements indicate substantial corrosion, then the extent of thickness measurements are to be increased to determine the extent of areas of substantial corrosion in accordance with Table 6.4.8.2.

6.3.3.3 In the case of ships other than those engaged in the carriage of dry cargoes only, an internal examination of selected cargo spaces is to be carried out.

6.3.4 Vessels of age more than 15 years

a) For vessels other than general dry cargo ships, in addition to the requirements given in 6.3.3, an internal examination of selected cargo holds is to be carried out.

b) For general dry cargo ships, the requirements of the intermediate survey is to be to the same extent as the previous special survey as required in 6.4 for hull structure and piping systems in way of the cargo holds, cofferdams, pipe tunnels, void spaces and fuel oil tanks in the cargo area and all ballast tanks. However, tank testing specified in 6.4.6, survey of automatic air pipe heads specified in 6.4.4.7 and internal examination of fuel oil, lub.oil and freshwater tanks specified in Table 6.4.4.1 need not be carried out unless deemed necessary by the Surveyor. In water survey complying with the requirements of 7.2 may be accepted in lieu of docking survey required by 6.4.1.11. Thickness measurement is to be carried out for items 1 to 4 of Table 6.4.8.1b except for item 2d).

In lieu of the application of 6.4.1.4, the intermediate survey may be commenced at the second annual survey and be progressed with a view to completion at the third annual survey.

6.4 Special surveys - Hull

6.4.1 General

6.4.1.1 All ships classed with IRS are to undergo Special Surveys at 5 yearly intervals. The first Special Survey is to be completed within 5 years from the date of the initial classification survey and thereafter 5 years from the assigned date of the previous Special Survey. However, an extension of class of 3 months maximum beyond the 5th year may be granted in exceptional circumstances in accordance with 1.11. In such cases, the next period of class will start from the expiry date of the Special Survey before extension was granted.

6.4.1.2 The interval between the Special Surveys may be reduced at the request of the parties concerned or by IRS if considered appropriate.

6.4.1.3 For surveys completed within 3 months before the expiry date of the Special Survey, the next period of class will start from the expiry date of the Special Survey. For surveys completed more than 3 months before the expiry date of the Special Survey, the period of class will start from the survey completion date. In cases where the vessel has been laid up or has been out of service for a considerable period because of a major repair or modification and the owner elects to only carry out the overdue surveys, the next period of class will start from the expiry date of the special survey. If the owner elects to carry out the next due special survey, the period of class will start from the survey completion date. Any requirement of the Flag Administration in this regard is also to be complied with.

6.4.1.4 The Special Survey may be commenced at the 4th Annual Survey and be progressed with a view to completion by the 5th anniversary date. When the special survey is commenced prior to the fourth annual survey, the entire survey is to be completed within 15 months if such work is to be credited to the special survey and in this case the next period of class will start from the survey completion date.

Concurrent crediting to both Intermediate survey and Special survey for surveys and thickness measurements of spaces is not acceptable.

6.4.1.5 For the purpose of special survey, results of thickness measurement carried out during or after the fourth annual survey only would be considered.

6.4.1.6 Record of Special Survey will not be assigned until the Machinery Survey has been completed or postponed in agreement with IRS.

6.4.1.7 Ships which have satisfactorily passed a Special Survey will have a record entered in the Supplement to the Register Book indicating the assigned date of Special Survey.

6.4.1.8 For vessels other than general dry cargo ships, IRS may, at the request of the Owners, accept a Special Survey of the hull on a continuous basis spread over a period of 5 years. Proposals for such continuous Surveys are to be submitted for the consideration of IRS. In general, approximately one-fifth of the Special Survey is to be completed every year. All compartments of the hull should be opened for Survey and testing in rotation such that not more than 5 years elapse between consecutive examination of each part.

The Surveyor may extend the inspection at his discretion, to other items if the inspections carried out reveal any defects.

The agreement for surveys to be carried out on a continuous survey system basis may be withdrawn at the discretion of IRS or on the request of Owners.

Ships on continuous survey system are not exempt from other periodical survey requirements. For ships more than 10 years of age, the ballast tanks are to be internally examined twice in each five-year class period, i.e. once within the scope of the intermediate survey and once within the scope of the continuous system for the hull special survey.

Ships which have completed satisfactorily the Survey of all the items on such basis will have a record entered in the supplement to the Register Of Ships indicating the date of completion of the Survey.

6.4.1.9 The special survey is to include, in addition to the requirements of the Annual Survey, examination, tests and checks of sufficient extent to ensure that the hull, equipment and related piping as required in 6.4.4.2 and 6.4.4.3 are in satisfactory condition and that the ship is fit for its intended purpose for the new period of class of five years to be assigned subject to proper maintenance and operation and the periodical surveys being carried out at the due dates.

6.4.1.10 The examinations of the hull are to be supplemented by thickness measurements (See 6.4.8) and testing as deemed necessary, to ensure that the structural integrity remains effective. The aim of the examination is to discover substantial corrosion, significant deformation, fractures, damages or other structural deterioration, that may be present.

6.4.1.11 A Docking Survey in accordance with the requirements of Sec.7 is to be carried out as part of the Special Survey. Any remaining work in respect of the overall and close-up surveys and thickness measurements, as applicable, of the lower portions of cargo holds and ballast tanks (i.e. parts below light ballast water line) are to be completed in dry dock.

6.4.2 Preparation for survey

6.4.2.1 The ship is to be prepared for overall survey in accordance with the requirements of Table 6.4.2.1. The preparation is to be of sufficient extent to facilitate an examination to ascertain any excessive corrosion, deformation, fractures, damages and other structural deterioration.

6.4.2.2 Prior to commencement of any part of the special survey, a survey planning meeting is to be held between the attending surveyor(s), the owner’s representative in attendance, the thickness measurement company representative and the master of the ship or an appropriately qualified representative appointed by the master or Company for the purpose to ascertain that all the arrangements envisaged in the survey programme are in place, so as to ensure the safe and efficient conduct of the survey work to be carried out.

Table 6.4.2.1 : Survey preparation

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequently** **Age > 15**
1) The holds, tween decks, deep tanks, peaks, bilges and drain wells, engine and boiler spaces, coal bunkers and other spaces are to be cleared out and cleaned as necessary for examination. Floor plates in engine and boiler spaces are to be lifted as may be necessary for examination of the structure underneath. Where necessary ceiling, lining, casings and loose insulation are to be removed as required by the Surveyor for examination of the structure. Compositions on the plating are to be examined and sounded, but need not be disturbed if found satisfactorily adhering to the plating.	1) Requirements of Special Survey I to be complied with	1) Requirements of Special Survey II to be complied with	1) Requirements of Special survey III to be complied with
2) In ships with single bottom, a sufficient amount of close ceiling is to be lifted to enable examination of the structure below. The ceilings to be lifted is to comprise of at least two strakes on each side of centreline fore and aft and one of these strakes is to be in way of the bilges	2) In ships having a single bottom, a sufficient amount of ceiling is to be lifted to allow the examination of the structure underneath. The lifting of the ceiling is to comprise of at least three strakes all fore and aft on each side and one such strake one each side to be in way of the bilges. Where the ceiling is fitted in hatches, the whole of the hatches and at least one strake of planks in way of the bilges on each side are to be lifted. If the Surveyor considers it necessary the whole of the ceiling and the limber boards are to be lifted	2) Ceiling in the holds is to be removed in order to ascertain that the steel work is in good condition, free from rust and coated. If the Surveyor is satisfied, after removal of portions of the ceiling, than it need not all be removed	2) Where holds are insulated for the purpose of carrying refrigerated cargoes, limbers and hatches are to be lifted and a sufficient additional amount of insulation is to be removed in each compartment to enable the Surveyor to ascertain the condition of the structure in way and to enable the thickness of the shell plating to be ascertained

Table 6.4.2.1 : (Contd.)			
Special Survey No. I Age ≤ 5	**Special Survey No. II 5 < Age ≤ 10**	**Special Survey No. III 10 < Age ≤ 15**	**Special Survey No. IV and subsequently Age > 15**
3) In ships having double bottom, a sufficient amount of ceiling is to be lifted from the tank top and the bilges to enable the condition of plating underneath to be ascertain. If the condition of the plating is found to be satisfactory, lifting of the remainder of the ceiling may be dispensed with. All bilges are to be cleaned for examination. Where the inner bottom plating is covered with cement or asphalt the removal of such covering may be dispensed with provided it is found to be adhering properly to the plating when carefully examined by hammering and chipping	3) In ships with double bottom, a sufficient amount of ceiling in the holds and other spaces is to be removed from the bilges and the inner bottom to enable the condition of the structure in the bilges, the inner bottom plating, pillar feet and the bottom plating of bulkheads and tunnel sides to be examined. If the Surveyor considers it necessary, the whole of the ceiling is to be removed	3) Portions of wood sheathing, or other covering, on steel decks are to be removed, as considered necessary by the Surveyor, in order to ascertain the condition of the plating	
4) Where holds are insulated for the carriage of refrigerated cargoes and the hull in way was examined by IRS Surveyors prior to the fitting of the insulation, it will be sufficient to remove the limbers and hatches for examination of the structure in way. In all other cases additional insulation will require to be removed as considered necessary to enable the Surveyor to satisfy himself regarding condition of the structure	4) The chain locker is to be cleaned internally. The chain cables are to be ranged for inspection. The anchors are to be cleaned and placed in an accessible position for inspection	4) Where the holds are insulated for the purpose of carrying refrigerated cargoes, the limbers and hatches are to be lifted and sufficient insulation is to be removed in each of the chambers to enable the Surveyor to satisfy himself of the condition of the framing and plating	
5) The steel work is to be exposed and cleaned as may be required for its proper examination by the Surveyor and close attention is to be paid to the parts of the structure which are particularly liable to excessive corrosion or to deterioration due to other causes			
6) All tanks are to be cleaned as necessary to permit examination required by Table 6.4.3.1			
7) Casings or covers of air, sounding, steam and other pipes, spar ceiling and lining in way of the side scuttles are to be removed, as required by the Surveyor			

Table 6.4.2.1 : (Contd.)			
Special Survey No. I Age ≤ 5	**Special Survey No. II 5 < Age ≤ 10**	**Special Survey No. III 10 < Age ≤ 15**	**Special Survey No. IV and subsequently Age > 15**
8) In refrigerated cargo spaces the condition of the coating behind the insulation is to be examined at representative locations. The examination may be limited to verification that the protective coating remains effective and that there are no visible structural defects. Where POOR coating condition is found, the examination is to be extended as deemed necessary by the Surveyor. The condition of the coating is to be reported. If indents, scratches, etc., are detected during surveys of shell plating from the outside, insulations in way are to be removed as required by the Surveyor, for further examination of the plating and adjacent frames.			

6.4.3 Space protection

6.4.3.1 For ballast tanks, excluding double bottom tanks, where a hard protective coating is found in POOR condition and it is not renewed or where soft or semi-hard coating has been applied, or where a hard protective coating was not applied from the time of construction, space in question is to be internally examined at annual surveys. Thickness measurements are to be carried out as deemed necessary by the Surveyor.

6.4.3.2 For double bottom ballast tanks where a hard protective coating is found in POOR condition and it has not been renewed or where soft or semi-hard coating has been applied, or where a hard protective coating was not applied from the time of construction, the spaces in question may be examined at Annual Surveys. When considered necessary by the surveyor, thickness measurements are to be carried out.

6.4.4 Survey and examination

6.4.4.1 All spaces within the hull and superstructure are to be examined.

6.4.4.2 All tanks are to be examined internally in accordance with the requirements of Table 6.4.4.1.

All bilge and ballast piping systems are to be examined and operationally tested to working pressure to attending Surveyor's satisfaction to ensure that tightness and condition remain satisfactory.

6.4.4.3 For general dry cargo ships, the following requirements are also to be applied:

- An overall survey of all cargo holds, pipe tunnels, cofferdams and void spaces bounding cargo holds, decks and outer hull is to be carried out.

- All piping systems within the above spaces and in ballast tanks are to be examined and operationally tested to working pressure to attending Surveyor's satisfaction to ensure that tightness and condition remains satisfactory.

- The survey extent of ballast tanks converted to void spaces is to be based on the requirement for ballast tanks.

Table 6.4.4.1 : Requirements for internal examination of tanks

Tank	Special Survey No. I Age ≤ 5	Special Survey No. II 5 < Age ≤ 10	Special Survey No. III 10 < Age ≤ 15	Special Survey No. IV and subsequent Age > 15
Fuel oil bunker tanks - Engine room - Cargo area	 None None	 None One	 One Two	 One Half the number of tanks, minimum 2
Lub.oil	None	None	None	One
Fresh water	None	One	All	All
Water ballast	All	All	All	All

Notes:

1) These requirements apply to tanks of integral (structural) type.

2) If a selection of tanks is accepted to be examined, then different tanks are to be examined at each special survey, on a rotational basis.

3) Peak tanks (all uses) are subject to internal examination at each special survey.

4) At special survey No.III and subsequent special surveys one deep tank for fuel oil in the cargo area is to be included, if fitted.

6.4.4.4 All watertight bulkheads and watertight doors are to be examined.

6.4.4.5 All decks, casings and superstructures are to be examined. Attention is to be given to the corners of openings and other discontinuities in way of the strength decks and top sides.

Wooden decks or sheathings are to be examined and if decay or rot is found or the wood is excessively worn, the wood should be renewed.

Attention is to be given to the condition of the plating under wood decks, sheathing or other deck coverings. Removal of such coverings may be dispensed with if they are found to be sound and adhering satisfactorily to the plating.

6.4.4.6 Engine room structure is to be examined. Particular attention being given to tank tops, shell plating in way of tank tops, brackets connecting side shell frames and tank tops and engine room bulkheads in way of tank tops and bilge wells. Where excessive areas of wastage are found, thickness measurements are to be carried out and renewals or repairs made when wastage exceeds allowable limits.

6.4.4.7 The hand pumps and suctions, air and sounding pipes are to be examined. The Surveyors are to ensure that striking plates are fitted under the sounding pipes whilst examining the tanks internally.

For vessel other than passenger ships, automatic air pipe heads are to be internally examined at special surveys as indicated in Table 6.4.4.7. For designs where the inner parts cannot be properly inspected from outside, the head is to be removed from the air pipe. Particular attention is to be paid to the condition of the zinc coating in heads constructed from galvanised steel.

6.4.4.8 The steering gear, and its connections and control systems (main and alternative) are to be examined. The auxiliary steering gear with its various parts are to be examined in working condition.

Table 6.4.4.7 : Requirements for internal examination of automatic air pipe heads

Location	Special survey No.I Age ≤ 5	Special survey No.II 5 < Age ≤ 10	Special survey No.III and subsequent Age > 10
forward 0.25L	Two air pipe heads[1,2] one port and one starboard on exposed decks	All air pipe heads on exposed decks	All air pipe heads[3] on exposed decks
aft of 0.25L from the forward perpendicular	Two air pipe heads[1,2] one port and one starboard on exposed decks	At least 20% of air pipe heads[1,2] on exposed decks	

1. Preferably air pipes serving ballast tanks.
2. The selection of air pipe heads is to be made by the attending Surveyor. According to the results of the inspection, the Surveyor may require additional air pipe heads to be examined.
3. When there is substantiated evidence of replacement within the previous five years, individual air pipe heads may not be examined.

6.4.4.9 The Surveyor should satisfy himself regarding the efficient condition of the following :

- Means of escape from machinery spaces, crew and passenger spaces and spaces in which crew are normally employed;

- Means of communication between bridge and engine room and between bridge and alternative steering position;

- Helm indicator;

- Protection to the aft steering wheel and the gear.

6.4.4.10 The masts, standing rigging and anchors are to be examined.

The Surveyor should satisfy himself that there are sufficient mooring ropes on board and also that a tow line is provided when this is a Rule requirement.

6.4.4.11 The chain cables are to be ranged and the anchors and the chain cables are to be examined. At special survey no. II and subsequent special surveys, the chain cables are to be gauged. Any length of chain cable which is found to have reduced in mean diameter at its most worn part by more than 12 per cent of its original rule diameter is to be renewed.

6.4.4.12 The windlass is to be examined.

6.4.4.13 The chain locker, hold fasts, hawse pipes and chain stoppers are to be examined and pumping arrangements of the chain locker tested.

6.4.4.14 The loading instrument is to be checked for accuracy by applying test load conditions in presence of the Surveyor.

6.4.4.15 For single hold cargo ships which require fitment of hold water level detectors as per Pt.4, Ch.3, Sec.3.6, the special survey is to include an examination and a test of the water ingress detection system and their alarms.

6.4.4.16 Examination of accommodation ladders, gangways and their winches are to be carried out as required for annual surveys. In addition, the accommodation ladders and gangways are to be operationally, tested with the specified maximum operation load.

The tests are to be carried out with the load applied as uniformly as possible along the length of the accommodation ladder or gangway, at an angle of inclination corresponding to the maximum bending moment on the accommodation ladder or gangway.

Accommodation ladder winch is to be operationally tested at special surveys. The brake system of the winch is to be tested for holding the maximum operational load on the ladder.

For existing installations on board ships constructed prior to 01 Jan 2010 where the maximum operational load is not known, load nominated by the shipowner or operator may be considered as the test load.

6.4.5 Hatch covers and coamings

6.4.5.1 In addition to the requirements of annual survey, the following examination/testing is to be carried out:

a) checking of the satisfactory operation of the mechanically operated hatch covers:

   - stowage and securing in open condition;

   - proper fit, locking and efficiency in closed condition;

   - operational testing of hydraulic and power components, wires, chains and link drives.

b) checking the effectiveness of sealing arrangements of all hatch covers by hose testing or equivalent.

c) checking the residual thickness of coamings, steel pontoon or hatch cover plating and stiffening members as deemed necessary by the Surveyor.

For general dry cargo ships, close-up survey and thickness measurement of plating and stiffeners of hatch cover and coaming is to be carried out as required by Table 6.4.7.1 and Table 6.4.8.1b. Close up survey/thickness measurement is to be carried out for accessible parts of hatch cover structures. For cargo hold hatch covers of approved design which have no access to internal structures, close up survey/thickness measurements of such inaccessible structural members need not be carried out.

6.4.6 Tank testing

6.4.6.1 Boundaries of double-bottom, deep, ballast, peak and other tanks, including holds adapted for the carriage of water ballast are to be tested with a head of liquid to the top of air pipes or to near the top of hatches for ballast/cargo holds. Boundaries of fuel oil, lub.oil and fresh water tanks are to be tested with a head of liquid to the highest point that liquid will rise under service conditions. Tank testing of fuel oil lub.oil and fresh water tanks may be specially considered based on a satisfactory external examination of the tank boundaries and a confirmation from the master stating that the pressure testing has been carried out according to the requirements with satisfactory results.

6.4.6.2 The Surveyor may extend the tank testing as may be necessary.

6.4.7 Close-up surveys of general dry cargo ships

6.4.7.1 The minimum requirements for close-up survey for general dry cargo ships are given in Table 6.4.7.1.

The surveyor may extend the close-up survey as deemed necessary taking into account the maintenance of the spaces under survey, the condition of the corrosion prevention system and where spaces have structural arrangements or details which have suffered defects in similar spaces or on similar ships according to available information.

6.4.7.2 For areas in tanks and cargo holds where coatings are found in GOOD condition, the extent of close-up examination may be specially considered.

Table 6.4.7.1 : Requirements of close-up survey – General dry cargo ships

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequent** **Age > 15**
(A) Selected shell frames in one forward and one aft cargo hold and associated tween deck spaces. (B) One selected cargo hold transverse bulkhead. (D) All cargo hold hatch covers and coamings (plating and stiffeners).	(A) Selected shell frames in all cargo holds and tween deck spaces. (B) One transverse bulkhead in each cargo hold. (B) Forward and aft transverse bulkhead in one side ballast tank, including stiffening system. (C)One transverse web with associated plating and framing in two representative ballast tanks of each type (i.e. topside, hopper side, side tank or double bottom tank). (D) All cargo hold hatch covers and coamings (plating and stiffeners). (E) Selected areas of all deck plating and underdeck structure inside line of hatch openings between cargo hold hatches. (F) Selected areas of inner bottom plating.	(A) All shell frames in the forward lower cargo hold and 25% frames in each of the remaining cargo holds and tween deck spaces including upper and lower end attachments and adjacent shell plating. (B) All cargo hold transverse bulkheads. (B) All transverse bulkheads in ballast tanks, including stiffening system. (C) All transverse webs with associated plating and framing in each ballast tank (D) All cargo hold hatch covers and coamings (plating and stiffeners). (E) All deck plating and underdeck structure inside line of hatch openings between cargo hold hatches. (F) All areas of inner bottom plating.	(A) All shell frames in all cargo holds and tween deck spaces including upper and lower end attachments and adjacent shell plating. Areas (B—F) as for Special Survey No.III

(A) Cargo hold transverse frames.

(B) Cargo hold transverse bulkhead plating, stiffeners and girders.

(C) Transverse web frame or watertight transverse bulkhead in ballast tanks.

(D) Cargo hold hatch covers and coamings. Close up survey/thickness measurement is to be carried out for accessible parts of hatch cover structures. For cargo hold hatch covers of approved design which have no access to internal structures, close up survey/thickness measurements of such inaccessible structural members need not be carried out.

(E) Deck plating and underdeck structure inside line of hatch openings between cargo hold hatches.

(F) Inner bottom plating.

Note : Close-up survey of cargo hold transverse bulkheads to carried out at the following levels:

- Immediately above the inner bottom and immediately above the tween decks, as applicable.
- Mid-height of the bulkheads for holds without tween decks.
- Immediately below the main deck plating and tween deck plating.

6.4.8 Thickness measurement

6.4.8.1 The minimum requirements for thickness measurement are given in Table 6.4.8.1a and Table 6.4.8.1b.

The Surveyor may extend the thickness measurements as deemed necessary.

Where thickness measurements indicate substantial corrosion, the number of thickness measurements are to be increased to determine the extent of substantial corrosion. Table 6.4.8.2 may be used as guidance for additional measurements.

Table 6.4.8.1a : Thickness measurement : General Ship Types (other than general dry cargo ships)

Special Survey No. I Age ≤ 5	**Special Survey No. II 5 < Age ≤ 10**	**Special Survey No. III 10 < Age ≤ 15**	**Special Survey No. IV and subsequently Age > 15**
1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel
	2) One transverse section of deck plating in way of cargo space within the amidships 0.5L	2) Two transverse sections in way of cargo spaces within the amidships 0.5L	2) A minimum of three transverse sections in way of cargo spaces within the amidships 0.5L
		3) Internals in forepeak and after peak tanks	3) Internals in forepeak and after peak tanks
		4) All cargo hold hatch covers and coamings (plating and stiffeners)	4) All cargo hold hatch covers and coamings (plating and stiffeners)
			5) All exposed main deck plating full length
			6) Representative exposed superstructure deck plating (poop, bridge and forecastle deck)
			7) Lowest strake and strakes in way of tween decks of all transverse bulkheads in cargo spaces together with internals in way
			8) All wind and water strakes, port and starboard, full length
			9) All keel plates full length. Also additional bottom plates in way of cofferdams, machinery space and aft end of tanks
			10) a) Plating of sea chests. b) Shell plating in way of overboard discharges as considered necessary by the Surveyor

Table 6.4.8.1a - **Notes**:

1) Thickness measurement locations are to be selected to provide the best representative sampling of areas likely to be most exposed to corrosion considering cargo and ballast history and arrangement and condition of protective coatings.
2) Thickness measurements of internals may be specially considered by the Surveyor if the hard protective coating is in GOOD condition.
3) For ships less than 100 [m] in length, the number of transverse sections required at Special Survey No.III may be reduced to one (1) and the number of transverse sections required at Subsequent Special Surveys may be reduced to two (2).
4) For ships equal to or more than 100 [m] in length, at special survey No.III, additional thickness measurements of exposed main deck plating within amidship 0.5L may be required.
5) Close up survey/thickness measurement is to be carried out for accessible parts of hatch cover structures. For cargo hold hatch covers of approved design which have no access to internal structures, close up survey/thickness measurements of such inaccessible structural members need not be carried out.

Table 6.4.8.1b : Thickness measurement : General dry cargo ships

Special Survey No. I **Age ≤ 5**	**Special Survey No. II** **5 < Age ≤ 10**	**Special Survey No. III** **10 < Age ≤ 15**	**Special Survey No. IV and subsequently** **Age > 15**
1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel	1) Suspect areas throughout the vessel
	2) Within the cargo area: One transverse section of deck plating in way of cargo space within the amidships 0.5L	2) Within the cargo area: a) Two transverse sections within the amidships 0.5L in way of two different cargo spaces b) Each deck plate outside line of cargo hatch openings c) All wind and water strakes	2) Within the cargo area: a) A minimum of three transverse sections within the amidships 0.5L b) Each deck plate c) All wind and water strakes d) Each bottom plate, including lower turn of bilge. e) Duct keel or pipe tunnel plating and internals
	3) Measurement for general assessment and recording of corrosion pattern of those structural members subject to close-up survey according to Table 6.4.7.1	3) Measurement for general assessment and recording of corrosion pattern of those structural members subject to close-up survey according to Table 6.4.7.1	3) Measurement for general assessment and recording of corrosion pattern of those structural members subject to close-up survey according to Table 6.4.7.1
		4) Selected wind and water strakes outside the cargo length area	4) All wind and water strakes outside cargo area
		5) Internals in forepeak tank	5) Internals in forepeak tank
			6) All exposed main deck plating outside cargo area
			7) Representative exposed super structure deck plating (poop, bridge and fore castle deck)
			8) All keel plates, additional bottom plates in way of machinery space, aft end of tanks and cofferdams outside cargo area
			9) a) Plating of sea chests. b) Shell plating in way of overboard discharges as considered necessary by the Surveyor

Table 6.4.8.1b - **Notes**:

1. Thickness measurement locations should be selected to provide the best representative sampling of areas likely to be most exposed to corrosion, considering cargo and ballast history and arrangement and condition of protective coatings.
2. For ships less than 100 metres in length, the number of transverse sections required at Special Survey No. III may be reduced to one and the number of transverse sections at Special Survey No. IV and subsequent surveys may be reduced to two.

6.4.8.2 For general dry cargo ships, representative thickness measurement to determine both general and local levels of corrosion in the shell frames and their end attachments in all cargo holds and ballast tanks is to be carried out.
Thickness measurement is also to be carried out to determine the corrosion levels on the transverse bulkhead plating.

The thickness measurements may be dispensed with provided the surveyor is satisfied by the close-up examination, that there is no structural diminution and the hard protective coating where applied remains efficient.

6.4.8.3 For areas in tanks where coating are found to be in a GOOD condition, the extent of thickness measurements may be specially considered by the Surveyor.

6.4.8.4 Transverse sections are to be chosen where the largest reductions are suspected to occur or are revealed from deck plating measurements.

6.4.8.5 The thickness measurements are to be carried out by a qualified firm certified by IRS.

6.4.8.6 In order to ensure necessary control during the process of thickness measurements, these are normally to be carried out under the supervision of the Surveyor. The Surveyor has the right to re-check the measurements as deemed necessary to ensure acceptable accuracy.

Table 6.4.8.2 : Guidance for additional thickness measurements in way of substantial corrosion

Structural Member	Extent of Measurement	Pattern of Measurement
Plating	Suspect area and adjacent plates	5 point pattern over 1 square meter
Stiffeners	Suspect area	3 measurements each in line across web and flange

6.4.8.7 A thickness measurement report is to be prepared. The report is to give the location of measurements, the thickness measured as well as corresponding original thickness. Furthermore, the report is to give the date when the measurements were carried out, type of measurement equipment, names of personnel and their qualifications and has to be signed by the operator. The Surveyor is to review the report of the final thickness measurement after repairs have been carried out and countersign the cover page.

6.4.9 Reporting and evaluation of survey of general dry cargo ships

6.4.9.1 The data and information on the structural condition of the vessel collected during the survey is to be evaluated for acceptability and continued structural integrity of the vessel.

6.4.9.2 The survey report would be issued to the owner and the same along with a copy of the thickness measurement report, verified and countersigned by the surveyor, is to be placed on board the vessel for reference at future surveys.

6.4.10 Shell and inner doors of ro-ro ships

6.4.10.1 The special survey is to include, in addition to the requirements of the Annual Survey as required in 6.2.6, examination, tests and checks of sufficient extent to verify that the bow, inner, side shell and stern doors, are in satisfactory condition and considered able to remain in compliance with applicable requirements, subject to proper maintenance and operation in accordance with the Operation and Maintenance Manual (OMM) or manufacturer's recommendations and the periodical surveys being carried out at the due dates for the five year period until the next Special Survey.

6.4.10.2 The examinations of the doors are to be supplemented by thickness measurements and testing to verify compliance with applicable requirements so that the structural and weathertight integrity remain effective. The aim of the examination is to identify corrosion, significant deformation, fractures, damages or other structural deterioration, that may be present.

6.4.10.3 The bow, inner, side shell and stern doors are to be surveyed as follows:

i) A survey of the items listed in 6.2.6.4, including close-up survey of securing, supporting and locking devices, together with welding, according to Table 6.2.6.4.

ii) Non-destructive testing and thickness measurements are to be carried out on securing, supporting and locking devices, including welding, to the extent considered necessary by the Surveyor. Whenever a crack is found, an examination with NDT is to be carried out in the surrounding area and for similar items as considered necessary by the Surveyor.

iii) The maximum thickness diminution of hinging arms, securing, supporting and locking devices is not to be more than 15% of the as-built thickness, in general.

iv) Effectiveness of sealing arrangements is to be verified by hose testing or equivalent.

v) Clearances of hinges, bearings and thrust bearings are to be taken. Unless otherwise specified in the OMM or by manufacturer's recommendation, the measurement of clearances on ro-ro cargo ships may be limited to representative bearings where dismantling is needed in order to measure the clearances.
If dismantling is carried out, a visual examination of hinge pins and bearings together with NDT of the hinge pin is to be carried out.

vi) The non-return valves of the drainage system are to be dismantled and examined.

6.4.11 For general dry cargo ships compliance with new IACS requirements for strength of air pipes, ventilators and their closing devices and of small hatches and their securing devices is to be achieved as indicated in 2.4.13.

6.5 Special surveys - Machinery

6.5.1 Requirements for examination of machinery and piping at special survey are given in Sec.8.

Section 7

Docking Surveys

7.1 General

7.1.1 The requirements for docking survey intervals are given in Table 1.1.1. Attention should also be given to any relevant statutory requirements of the National Authority of the country in which the ship is registered.

An extension of examination of the ship's bottom of 3 months beyond the due date can be granted in exceptional circumstances due to any of the following reasons:

a) Non-availability of drydocking facilities, repair facilities, essential materials, equipment or spare parts.

b) Delays incurred by action taken to avoid severe weather conditions or delays caused by severe weather conditions.

7.1.2 The ship is to be placed on blocks of sufficient height in a drydock or on a slipway and proper staging is to be erected as may be necessary. Shell plating, stern frame or stern post, rudder and sea inlet and discharge openings are to be examined. Particular attention is to be given to the bilge keels and their connection to the bilge strake, shell plating in way of side, bow and stern doors, ash shoots, and other openings and to parts of the structure particularly liable to excessive corrosion or to deterioration from causes such as chafing and lying on the ground and to any undue unfairness of the bottom plating. Important plate unfairness or other deterioration which do not necessitate immediate repairs are to be recorded.

Visible parts of rudder, rudder pintles, rudder shafts and couplings are to be examined. The clearances in the rudder bearings are to be ascertained. The rudder is to be lifted for examination of the pintles, if considered necessary by the Surveyor. Where applicable, pressure test of the rudder may be required as considered necessary by the Surveyor.

7.1.3 When the chain cables are ranged the anchors and cables should be examined by the Surveyor.

7.1.4 Sea chests and their gratings, sea connections and overboard discharge valves and cocks and their fastenings to the hull or sea chests are to be examined. Valves and cocks need not be opened up more than once in a special survey period unless considered necessary by the Surveyor.

7.1.5 The Surveyor should examine the ship so far as is practicable in order to satisfy himself as to her general condition.

7.1.6 The propeller should be examined for erosion, pitting, cracking of blades or possible contact damage. The clearance in the stern bush should be measured. In the case of approved oil glands, measurements by poker gauges or other devices for ascertaining the stern bush weardown may be accepted, provided the sealing arrangements appear satisfactory.

7.1.7 For controllable pitch propellers, the Surveyor is to be satisfied with the fastenings and tightness of hub and blade sealing. Dismantling need not be carried out unless considered necessary by the Surveyor.

7.1.8 Exposed parts of side thrusters are to be examined. Propulsion systems which also have maneuvering characteristics(such as directional propellers, vertical axis propellers, water jets) are to be examined externally with focus on the condition of gear housing, propeller blades, bolt locking and other fastening arrangements. Sealing arrangement of propeller blades, propeller shaft and steering column is to be verified.

7.2 In-water surveys

7.2.1 Eligibility

7.2.1.1 For ships less than 15 years in age the examination of the outside of ship's bottom and related items of ships may be carried out while the ship is afloat (inwater survey) in lieu of the required intermediate docking between special surveys provided following conditions are satisfied.

a) The ship has been assigned the class notation INWATER SURVEY as defined in Ch.1. However, on application by the owner and in special circumstances, such inwater survey may be considered for ships not assigned with the class notation INWATER SURVEY.

b) The ship does not have any outstanding recommendations which require repair work in dry dock to the underwater part of the shell plating, the rudder, the propeller or the propeller shaft.

7.2.1.2 Acceptance of inwater surveys as above may be specially considered for ships other than bulk carriers, oil tankers and chemical tankers which are 15 years of age and over.

7.2.2 Requirements for assignment of INWATER SURVEY notation

7.2.2.1 Detailed plans of the hull and hull attachments below the water line are to be submitted to IRS in triplicate for approval. These plans are to indicate the location and/or the general arrangement of:

- all shell openings
- stem
- rudder and fittings
- sternpost
- propeller, including the means used for identifying each blade
- anodes, including securing arrangements
- bilge keels
- welded seams and butts.

The plans are also to include the necessary instructions to facilitate the divers' work, especially for taking clearance measurements.

7.2.2.2 The plans for approval are also to include the procedure for measurement or verification, as the case may be, of the following:

- rudder pintle/bush clearance
- stern bush clearance
- pintle securing arrangement in the socket.

7.2.2.3 As far as practicable, a photographic documentation, used as a reference during the in-water surveys, of the following hull parts is to be submitted to IRS:

- propeller boss
- rudder pintles, where slack is measured
- typical connections to the sea
- directional propellers, if any
- other details, as deemed necessary by IRS on a case by case basis.

7.2.2.4 The Owner is to put on board the ship the plans and documents given in 7.2.2.1 and 7.2.2.2 and they are to be made available to the Surveyor and the divers when an in-water survey is carried out.

7.2.2.5 Protection for the underwater portion of the hull is to be provided by means of a suitable coating of adequate thickness to last more than the scheduled intervals between consecutive dry dockings and applied in accordance with the Manufacturer's recommendations.

7.2.3 Survey requirements

7.2.3.1 The in-water survey is to provide all the information normally obtained from a docking survey. However, special consideration may be given to ascertaining rudder bearing clearances and stern bush clearances of oil stern bearings based on a review of the operating history, on board testing and stern tube oil sample reports. These details are to be included in the proposals for in-water surveys which are to be submitted in advance of the survey so that satisfactory arrangements can be agreed with IRS.

7.2.3.2 The in-water survey is to be carried out with the ship in as light condition as possible in sheltered water preferably with weak tidal streams and currents. The in-water visibility and the cleanliness of the hull below the waterline is to be good enough to permit a meaningful examination which allows the Surveyor and diver to determine the condition of the plating, appendages and the welding. IRS is to be satisfied with the methods of orientation of the divers on the plating, which should make use where necessary of permanent markings on the plating at selected points.

7.2.3.3 The in-water survey is to be carried out by a person who is a skilled diver and trained to carry out in-water survey, or a qualified diver under surveillance of a Surveyor. The diver has to be employed by a firm approved by IRS.

The equipment, procedure for observing and reporting the survey are to be discussed with the parties involved prior to the in-water survey and suitable time is to be allowed to enable the diving company to test all equipment beforehand.

7.2.3.4 When professional divers are employed, the Surveyor is to be satisfied with the method of pictorial representation, and a good two-way communication between the Surveyor and divers is to be provided.

7.2.3.5 If the in-water survey reveals damage or a deterioration that requires early attention, the Surveyor may require that the ship to be drydocked in order that a detailed survey can be undertaken and the necessary repairs carried out.

7.2.3.6 The condition of the coating is to be confirmed at every drydocking for continuance of the INWATER SURVEY notation.

Section 8

Machinery - Special Surveys

8.1 General

8.1.1 Special surveys are to be carried out at 5 years intervals to renew the Class Certificate.

The first Special survey is to be completed within 5 years from the initial classification survey and thereafter 5 years from the assigned date of the previous special survey. However, an extension of class of 3 months maximum beyond the 5th year can be granted in exceptional circumstances.

In this case, the next period of class will start from the expiry date of the special survey before the extension was granted.

8.1.2 For surveys completed within 3 months before the expiry date of the special survey, the next period of class will start from the expiry date of the special survey. For surveys completed more than 3 months before the expiry date of the special survey, the period of class will start from the survey completion date. In cases where the vessel has been laid up or has been out of service for a considerable period because of a major repair or modification and the owner elects to only carry out the overdue surveys, the next period of class will start from the expiry date of the special survey. If the owner elects to carry out the next due special survey, the period of class will start from the survey completion date.

Any requirement of the Flag Administration in this regard is also to be complied with.

8.1.3 The special survey may be commenced at the 4th annual survey and be progressed with a view to completion by the 5th anniversary date. When the special survey is commenced prior to the 4th annual survey, the entire survey is to be completed within 15 months if such work is to be credited to the special survey.

8.1.4 Upon satisfactory completion of the Machinery Special Survey an appropriate record will be entered in the supplement of register of ships.

8.1.5 Further parts of machinery may require to be opened should any defects be found during the course of Survey of any item and the defects made good to the satisfaction of the Surveyor.

8.1.6 As part of the Special Survey of Machinery, a dock trial is to be carried out to attending Surveyor's satisfaction to confirm satisfactory operation of main and auxiliary machinery. If significant repairs are carried out to main or auxiliary machinery or steering gear, consideration should be given to a sea trial to attending Surveyor's satisfaction.

8.2 Continuous survey of machinery (CSM)

8.2.1 At the request of the Owners and upon approval of the proposed arrangement a system of continuous Survey of Machinery (CSM) may be undertaken whereby the requirements of Special Survey of machinery are completed within a five year period. The Survey cycle should be such as would ensure that the interval between consecutive examination of each item does not exceed five years and it is expected that approximately an equal proportion of the machinery would be subjected for Survey each year.

8.2.2 Upon satisfactory completion of the continuous Machinery Survey cycle, a record indicating the date of completion of the cycle will be shown in the supplement to the Register Of Ships.

8.3 Survey requirements: Auxiliary engines

8.3.1 All auxiliary engines driving the generators and other essential machinery together with their coolers and attached pumps are to be opened up and examined as considered necessary by the Surveyor. Alarms and safety devices fitted on these units are to be included in this Survey.

8.4 Survey requirements: Air compressors, receivers and starting air pipes

8.4.1 All air receivers and other pressure vessels for essential services together with their mountings and safety devices are to be cleaned internally and examined internally and externally. If an internal examination of an air receiver is not practicable it is to be tested hydraulically to 1.3 times the working pressure.

8.4.2 Air compressors are to be opened up and coolers tested as considered necessary by the Surveyor. Selected pipes in the starting air systems are to be removed for internal examination and hammer tested. If an appreciable amount of lubricating oil is found in the pipes the starting air system is to be thoroughly cleaned by steaming or other suitable means. Some of the pipes selected are to be those adjacent to the starting air valves at the cylinders and to the discharges from the air compressors.

8.5 Survey requirements: Fresh water generators and evaporators

8.5.1 To the extent applicable, these are to be opened up and examined. After such Survey their relief valves are to be checked under working conditions, where practicable.

8.6 Survey requirements: Fuel tanks

8.6.1 Fuel tanks which do not form part of the ship's structure are to be examined externally and, if considered necessary by the Surveyor also internally. All mountings, fittings and remote control devices are to be examined as far as practicable. All such tanks are to be tested by filling to maximum working level.

8.7 Survey requirements: Pumps, heat exchangers, forced draught fans, etc.

8.7.1 All pumps, heat exchangers, forced draught fans, etc. used for essential purposes are to be opened up and examined as considered necessary by the Surveyor.

8.8 Survey requirements: Pumping and piping system

8.8.1 The valves, cocks and strainers of the bilge system including bilge injection are to be opened up as considered necessary by the Surveyor and, together with pipes, are to be examined and tested under working conditions. If non-return valves are fitted in hold bilges, these be opened up for examination.

8.8.2 The oil fuel, feed and lubricating systems and ballast connections and blanking arrangements to deep tanks which may carry liquid or dry cargoes, together with all pressure filters, heaters and coolers used for essential service, are to be opened up and examined or tested as considered necessary by the Surveyor. All safety devices for the foregoing are to be examined.

8.8.3 Non-metallic expansion joints in piping systems, if located in system which penetrates the ship's side and both the penetration and the non-metallic expansion joint are located below the deepest load waterline, are to be examined and replaced as necessary or at an interval recommended by the manufacturer.

8.9 Survey requirements: Reduction gears, flexible couplings and clutch arrangements

8.9.1 Reduction gears, flexible couplings and clutch arrangements are to be opened as considered by the Surveyor in order to permit the examination of the gears, gear teeth, spiders, pinions, shafts and bearings, reversing gears, etc. Essential parts of other power transmission arrangements are to be opened up and examined as considered necessary by the Surveyor.

8.10 Survey requirements: Securing arrangements

8.10.1 Holding down bolts and chocks of main and auxiliary engines, gear cases, thrust blocks and tunnel bearings are to be checked.

8.11 Survey requirements: Shafting

8.11.1 Intermediate shafts and bearings, thrust bearings and their seating are to be examined. The lower halves of bearings need not be exposed if alignment and wear are found acceptable.

8.12 Survey requirements: Sea connections

8.12.1 All openings to the sea including sanitary and other overboard discharges in the machinery spaces and pump rooms together with valves and cocks are to be examined internally and externally. The fastenings of valves and cocks to the hull are to be examined and are to be renewed when considered necessary by the Surveyor. Particular attention is to be given to the sea suctions and sea water cooling pipes.

8.13 Survey requirements: Windlass and steering machinery

8.13.1 These are to be examined to ascertain that they are in good working order. Any relief valves fitted are to be included in the above examination.

8.14 Survey requirements: Internal combustion engines for propulsion

8.14.1 All working parts of the engines and their attached pumps are to be opened and examined. These should include all cylinders, cylinder heads, valves and valve gear, pistons, piston rods, cross heads, guides, connecting rods, crankshafts, vibration dampers and all bearings, camshafts and driving gear, fuel pumps and fittings, scavenge pumps, scavenge blowers and their prime movers, superchargers, air compressors, inter coolers, clutches, reverse gears, crankcase door fastenings and explosion relief devices and such other parts of the machinery as may be considered necessary. Integral piping systems are to be examined. The maneuvering of engines is to be tested under working condition.

8.15 Survey requirements: Steam turbines for propulsion

8.15.1 Upper halves of turbine casings are to be opened up rotors to be lifted up and inside of casings, rotors and bearings (including thrust) and governors to be examined.

8.15.2 At the first Special Periodical Survey only, for vessels having more than one main propulsion ahead turbine with emergency steam crossover arrangement, the turbine casings need not be opened provided approved vibration indicators and rotor position indicators are fitted and that the Surveyor considers the operating records to be satisfactory. An operational test of the turbines may be required if considered necessary by the Surveyor.

8.15.3 Essential valves attached to the turbines and flexible couplings are to be examined. The maneuvering of the turbines is to be tested under working conditions.

8.15.4 Exhaust steam turbines supplying power for main propulsion purposes in conjunction with reciprocating engines together with their gearing and appliances, steam compressors or electrical machinery are to be examined as far as practicable. Where cone connections to internal gear shafts are fitted, the coned ends are to be examined as far as practicable. The maneuvering of engines is to be tested under working conditions.

8.16 Survey requirements: Steam reciprocating engines for propulsion

8.16.1 Working parts of main engines and attached pumps including bulkhead stop valves, maneuvering valves, cylinders, pistons, valves and valve gear, piston rods, connecting rods, crankshaft and bearings and governor are to be opened up and examined. The maneuvering of engines is to be tested under working conditions.

8.17 Survey requirements: Gas turbines and free piston gas generators for propulsion

8.17.1 The Survey should include opening and examination of the following parts :-

- The blading, rotors, and casings of the turbines, the impellers or blading, rotors and casing of air compressors, the combustion chambers, burners, inter coolers, heat exchangers, gas and air pressure piping and fittings and reversing arrangements. When gas turbines operate in conjunction with free piston gas generators, the following parts of the free piston gas generators are to be opened and examined: the gas and air compressor cylinders and pistons and the compressor end covers, the valves and valve gear, fuel pumps and fittings, synchronising and control gear, cooling system explosion relief devices, gas and air piping, receivers and valves including by-pass. The maneuvering of engines is to be tested under working conditions.

8.18 Survey requirements: Unattended machinery spaces/Remote control systems

8.18.1 Where remote and/or automatic controls such as bridge controls, bilge controls and bilge level alarms, local hand controls, fire detection and prevention, alarms warning systems and shut-offs, electric supply, main controls station, are fitted for essential machinery, they are to be examined and tested to demonstrate that they are in good working order.

8.18.2 During such trials the proper operation of the safety devices will be checked, in particular, such as emergency stops, emergency astern movement, standby control of the propelling gear, fire alarm.

8.18.3 The log recording the operating conditions should be checked. If such scrutiny reveals that certain portion of the automated equipment has behaved abnormally the cause of such failure is to be investigated and appropriate remedies determined.

8.19 Survey requirements : Electrical equipment survey

8.19.1 Electrical installations including auxiliary and emergency equipment are to be examined in accordance with the following during each Survey cycle.

8.19.2 Switch boards (including for emergency use) and their accessories including section-boards and sub-division fuse boards are to be examined as far as possible and over current protective devices and fuses inspected to verify that they provide suitable protection for their respective circuits.

8.19.3 All generator circuit breakers are to be tested, as far as practicable, to verify that the protective devices including preference tripping relays, if fitted, operate satisfactorily. The generators are to be run under load either separately or in parallel, and the governing of the engines to be tested.

8.19.4 The insulation resistance of cables, switch gear, generators, motors, heaters, lighting and other fittings is to be tested and should not be less than 100,000 ohms between all insulated circuits and earth. The installation may be subdivided to any desired extent by opening switches, removing fuses or disconnecting appliances for the purpose of this test.

The electric cables are to be examined as far as possible without undue disturbance of fixtures or casings unless deemed necessary by the Surveyor.

8.19.5 Transformers are to be examined. Samples of oil are to be taken and tested for breakdown voltage, acidity and moisture in case of oil immersed transformers or electrical apparatus associated with supplies to essential services. The testing is to be carried out by a competent testing authority and a certificate giving the test results is to be furnished to the Surveyor.

8.19.6 Motors used for essential services including their starters are to be examined, and under working conditions if considered necessary by the Surveyors.

8.19.7 Generators and steering gear motors are to be examined under working conditions. Air gaps are to be checked for excessive wear down.

8.19.8 In the case of electromagnetic couplings, the air gaps are to be measured and reported and any excessive eccentricity corrected. Switch gear and couplings for same are to be examined and tested.

8.19.9 The emergency source of power and its associated circuits are to be tested. In the case of passenger ships, the temporary source of power and its automatic arrangements (if fitted) are also to be tested.

8.19.10 Navigation light indicators are to be tried under working conditions, and correct operation on the failure of supply or failure of navigation lights verified.

8.19.11 In tankers, a General examination of electrical equipment located in dangerous zones and spaces is to be made to ensure that the integrity of the safe type electrical equipment has not been impaired owing to corrosion, missing bolts, etc. Cable runs are to be examined for sheath and armouring defects, where practicable, and to ensure that the means of supporting the cable are in good order. Tests are to be carried out to demonstrate the effectiveness of earth bonding straps. Alarms and interlocks associated with pressurized equipment or spaces are to tested for correct operation.

Insulation resistance is to be measured for circuits terminating in, or passing through dangerous zones or spaces.

8.20 Survey requirements : Electrical propelling machinery

8.20.1 On ships which are electrically propelled, the main propulsion motors, generators, cables, together with all ancillary electrical gear, exciters and ventilating plant (including coolers) are to be examined and their insulation resistance to earth to be measured. Protective gear and alarm devices are to be checked as far as practicable and special attention should be given to windings, commutators and slip rings. Safety interlocks intended to prevent unsafe operation or unauthorised access are to be checked to verify that they are functioning correctly. Emergency over speed governors are to be tested. Where insulating oil is used, samples of oil are to be taken and tested for breakdown voltage, acidity and moisture by a competent testing authority and a certificate giving the test results is to be furnished to the Surveyor.

8.21 In service testing of large permanently installed breathing gas containers onboard diving vessels - Special Requirements

8.21.1 At the first special survey, following is to be carried out:

- External and internal survey, by intrascope if necessary.

- If internal survey is not possible or if corrosion or other items of concern are found, hydraulic test to 1.25 x design pressure to be carried out.

At subsequent special surveys, following to be carried out:

- External and internal survey, by intrascope if necessary.

- Hydraulic test to 1.25 x design pressure.

Section 9

Boiler Surveys

9.1 General

9.1.1 All main and auxiliary boilers, exhaust gas steam generators and economisers are to be surveyed at intervals specified in Sec.1 of this Chapter. An extension of examination of the boiler of up to 3 months beyond the due date can be granted in exceptional circumstances. “Exceptional Circumstances” means unavailability of repair facilities, unavailability of essential materials, equipment or spare parts, or delays incurred by action taken to avoid severe weather conditions.

9.1.2 At each Survey, the boilers, superheaters, economisers, air heaters, desuperheaters, and other equipment are to be examined internally (water/steam side) and externally (fire side) as considered necessary.

In exhaust gas heated economizers of the shell type, all accessible welded joints are to be subjected to a visual examination for detection of cracks. Nondestructive testing may be required for this purpose.

9.1.3 Boiler safety valve and its relieving gear are to be examined and tested to verify satisfactory operation. The adjustment of the safety valves is to be verified during each boiler internal survey. Safety valves are to be adjusted to a pressure not greater than 3 percent of the approved working pressure.

9.1.4 Review of the following records since the last boiler survey is to be carried out as part of the survey:

a) Operation
b) Maintenance
c) Repair history
d) Feed water chemistry

9.1.5 External survey of boilers including test of safety and protective devices and test of safety valve using its relieving gear, is to be carried out annually, within the window of the Annual Survey of a ship. For exhaust gas heated economizers, the safety valves are to be tested by the Chief Engineer at sea within the annual survey window. This test is to be recorded in the log book for review by the attending Surveyor prior to crediting the Annual Survey of Machinery.

9.1.6 Principal boiler mountings and safety valves are to be examined at each Survey. The remaining mountings are to be opened if considered necessary by the Surveyor. Manhole and hand hole doors, are to be examined to ensure that the joining faces are in good condition and that the clearances at the spigot are satisfactory.

9.1.7 In case where it is considered necessary, the parts subjected to pressure are to be hydraulically tested and the thickness of plates and size of stays ascertained to determine the safe working pressure. Collision chocks, rolling stays and boiler stools are to be examined and maintained in efficient condition. The shell plating in way of welded lugs or fabricated feet are to be carefully examined at each Survey. Insulation and sheathing in way are to be removed as considered necessary for this purpose.

In fired boilers employing forced circulation the pumps used for this purpose are to be opened and examined at each boiler Survey.

9.1.8 The proper operation of the water level indicators are to be confirmed at each Survey. The oil fuel burning system is to be examined under working conditions and a general examination made of the fuel tank valves, pipe, deck control gear and oil discharge pipes between pumps and burners.

GUIDANCE :

Every effort should be made to complete the boiler Survey once it has been commenced at the same port if possible or immediately afterwards on the first occasion when steam is raised.

9.1.9 An extension of survey may be granted by IRS, on the basis of 9.1.1, after the following is satisfactorily carried out:

a) External examination of the boiler

b) Boiler safety valve relieving gear (easing gear) is examined and operationally tested.

c) Boiler protective devices operationally tested.

d) Review of the records since the last boiler survey as mentioned in 9.1.4.

9.2 Steam heated steam generator

9.2.1 Steam heated steam generators are to be surveyed at two and half yearly intervals.

9.2.2 At each steam heated steam generator survey the mountings and the safety valves are to be examined. Manhole and hand hole doors are to be examined to ensure that joining faces are in good condition and that the clearances at the spigot are satisfactory.

9.2.3 Where it is considered necessary, parts subjected to pressure are to be hydraulically tested and the thickness of plates and the sizes of stays ascertained to determine the safe working pressure.

9.2.4 The proper operation of the water level indicators is to be confirmed at each Survey. The safety valves of the steam heated steam generator are to be adjusted to a pressure not greater than 3 per cent above the approved working pressure.

Section 10

Steam Pipes Surveys

10.1 General

10.1.1 Steam pipes are to be surveyed at intervals specified in Sec.1 of this Chapter.

10.1.2 At each Survey a selected number of main and auxiliary steam pipes over 75 [mm] bore supplying steam for essential services are to be examined internally and tested hydraulically to 1.5 times the working pressure. If these are found satisfactory, the remaining need not be tested. In cases of pipes having welded joints, the lagging in way of the welds is to be removed and the welds examined and if considered necessary crack detected.

10.2 Cylindrical boilers having smoke tube superheaters

10.2.1 Where the saturated steam pipes adjoining the saturated steam headers are situated partly in the boiler smoke boxes, all such pipes adjoining and cross connecting these headers in the smoke boxes are required to be included in the pipes required for examination and testing for the steam pipe Survey.

10.3 Copper pipes

10.3.1 At 10 years from the date of build, or of installation and thereafter at 5 yearly intervals, all copper pipes over 75 [mm] bore and supplying steam for essential services at sea are to be hydraulically tested to twice the working pressure. Pipes which are subjected to bending and/or vibration are to be annealed before testing.

Section 11

Surveys of Propeller Shafts, Tube Shafts and Propellers

11.1 General

11.1.1 At shaft surveys, propeller shafts and tube shafts, if any, are to be sufficiently drawn to permit entire examination at intervals as detailed in Sec.1 of this Chapter.

Unless alternative means are provided to ensure the condition of the propeller shaft assembly, these requirements apply to all vessels with conventional shafting fitted with a propeller as follows:

.1 from 1 Jan 2016 for ships delivered on or after 1 Jan 2016;

.2 after the first shaft survey scheduled on or after 1 Jan 2016, for ships delivered before 1 Jan 2016. Upon completion of the first shaft survey scheduled on or after 1 Jan 2016, the designation of dates for the next shaft survey is to be made based on the requirements in this section.

11.1.2 For the purpose of these requirements, the following definitions are applicable:

.1 Shaft is a general definition that could mean :

- Propeller shaft
- Tube shaft

The definition does not include the intermediate shaft(s) which is (are) considered part of the propulsion shafting inside the vessel.

.2 *Propeller Shaft.* Propeller shaft is the part of the propulsion shaft to which the propeller is fitted. It may also be called screwshaft or tailshaft. Where a separate tube shaft is not fitted, the propeller shaft runs through the stern tube and is connected to the intermediate shaft within the ship. In this case, only the propeller shaft and intermediate shaft are fitted and there is no tube shaft.

.3 *Tube Shaft.* Tube shaft is a shaft placed between the intermediate shaft and propeller shaft, normally arranged within a stern tube or running in open water. It may also be called Stern Tube Shaft.

.4 *Stern Tube*. Tube or pipe fitted in the shell of a ship at the stern (or rear part of the ship), below the water-line, through which passes the tube shaft or the propeller-shaft. Stern tube is the housing of the shaft bearings, generally two (one aft and one fore), that sustain the shaft and allows its rotation with less frictional resistance. The stern tube also accommodates the shaft sealing arrangement.

.5 *Close Loop (system) Oil Lubricated Bearing*. Closed loop oil lubricating systems use oil to lubricate the bearings and are sealed against the environment (seawater) by adequate sealing / gland devices.

.6 *Water Lubricated Bearing*. Water lubricated bearings are bearings cooled / lubricated by water (fresh or salt).

.7 *Closed Loop System Fresh Water Lubricated Bearing*. Closed loop water lubricating systems use fresh water to lubricate the bearings and are sealed against the environment (such as seawater) by adequate sealing / gland devices.

.8 *Open Systems (water)*. Open water lubricating systems use water to lubricate the bearings and are exposed to the environment.

.9 *Adequate means for protection against corrosion*. An adequate means for protection against corrosion is an approved means for full protection of the core shaft against sea water intrusion and subsequent corrosion attack. Such means are used for the protection of common steel material against corrosion particularly in combination with water lubricated bearings. Typical means are for example:

- continuous metallic, corrosion resistant liners,
- continuous cladding,
- multiple layer synthetic coating,
- multiple layer of fiberglass,
- combinations of above mentioned,
- rubber / elastomer covering coating.

The means for protection against corrosion are installed / applied according to IRS approved procedures.

.10 *Corrosion Resistant Shaft*. Corrosion resistant shaft is made in approved corrosion resistant steel as core material for the shaft.

.11 *Sterntube Sealing System*. Sterntube sealing system is the equipment installed on the inboard extremity and, for closed systems, at outboard extremity of the sterntube.

Inboard Seal is the device fitted on the fore part of the sterntube that achieve the sealing against the possible leakage of the lubricant media in to the ship internal.
Outboard seal is the device fitted on the aft part of the sterntube that achieve the sealing against the possible sea water ingress and the leakage of the lubricant media.

.12 *Service Records*. Service records are regularly recorded data showing in-service conditions of the shaft(s) and may include, as applicable: lubricating oil temperature, bearing temperature and oil consumption records (for oil lubricated bearings) or water flow, water temperature, salinity, pH, make-up water and water pressure (for closed loop fresh water lubricated bearings depending on design).

.13 *Oil sample examination*. An oil sample examination is a visual examination of the stern tube lubricating oil taken in presence of the surveyor with a focus on water contamination.

.14 *Lubricating oil analysis*. Lubricating oil analysis is to be carried out at regular intervals not exceeding six (6) months. The documentation on lubricating oil analysis is to be available on board.

Oil samples, to be submitted for the analysis, are to be taken under service conditions.

.15 *Fresh water sample test*. Fresh water sample test is to be carried out at regular intervals not exceeding six (6) months
Samples are to be taken under service conditions and are to be representative of the water circulating within the sterntube. Analysis results are to be retained on board and made available to the surveyor. At time of survey the sample for the test is to be taken in the presence of the surveyor.

Fresh water sample test is to include the following parameters:

- chlorides content,
- pH value,
- presence of bearing particles or other particles (only for laboratory analysis, not required for tests carried out in presence of the surveyor).

.16 *Keyless Connection*. Keyless connection is the forced coupling methodology between the shaft and the propeller without a key achieved through interference fit of the propeller boss on the shaft tapered end.

.17 *Keyed Connection*. Keyed connection is the forced coupling methodology between the shaft and the propeller with a key and keyway achieved through the interference fit of the propeller boss on the shaft tapered end.

.18 *Flanged Connection.* Flanged connection is the coupling methodology, between the shaft and the propeller, achieved by a flange, built in at the shaft aft end, bolted to propeller boss.

.19 *Alternative Means*. Alternative means are shafting arrangements with configuration other than those described in these requirements.

11.2 Oil Lubricated Shafts or Closed Loop System Fresh Water Lubricated Shafts (Closed System)

11.2.1 Shaft Survey Methods

11.2.1.1 **METHOD 1**

.1 The survey is to consist of:

- Drawing the shaft and examining the entire shaft, seals system and bearings;

- For keyed and keyless connections:

  - Removing the propeller to expose the forward end of the taper,

  - Performing a non-destructive examination (NDE) by an approved surface crack-detection method all around the shaft in way of the forward portion of the taper section, including the keyway (if fitted).
    For shaft provided with liners the NDE is to extend to the after edge of the liner.

- For flanged connection:

  - Whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul, repairs or when deemed necessary by the surveyor, the coupling bolts and flange radius are to be examined by means of an approved surface crack detection method.

- Checking and recording the bearing clearances;

- Verification that the propeller is free of damages which may cause the propeller to be out of balance;

- Verification of the satisfactory conditions of inboard and outboard seals during the re-installation of the shaft and propeller;

- Recording the bearing wear down measurements (after re-installation)

11.2.1.2 **METHOD 2**

.1 The following are to be verified and found satisfactory as a pre-requisite for application of Method 2:

- Review of service records;

- Review of test records of:

  - Lubricating Oil analysis (for oil lubricated shafts), or

  - Fresh water sample test (for closed system fresh water lubricated shafts);

- Oil sample examination (for oil lubricated shafts), or fresh water sample test (for closed system fresh water lubricated);

- Verification that there are no repairs by grinding or welding of shaft and/or propeller.

.2 The survey is to consist of:

- For keyed and keyless connections:

  - Removing the propeller to expose the forward end of the taper;
  - Performing a non-destructive examination (NDE) by an approved surface crack-detection Method all around the shaft in way of the forward portion of the taper section, including the keyway (if fitted).

- For flanged connection:

  - Whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul, repairs or when deemed necessary by the surveyor, the coupling bolts and flange radius are to be examined by means of a an approved surface crack detection Method.

- Checking and recording the bearing wear down measurements;

- Visual Inspection of all accessible parts of the shafting system;

- Verification that the propeller is free of damages which may cause the propeller to be out of balance;

- Seal liner found to be or placed in a satisfactory condition;

- Verification of the satisfactory re-installation of the propeller including verification of satisfactory conditions of inboard and outboard seals.

11.2.1.3 **METHOD 3**

.1 The pre-requisites for application of Method 3, are the same as those given in 11.2.1.2.1

.2 The survey is to consist of

- Checking and recording the bearing wear down measurements;

- Visual Inspection of all accessible parts of the shafting system;

- Verification that the propeller is free of damage which may cause the propeller to be out of balance;

- Seal liner found to be or placed in a satisfactory condition;

- Verification of the satisfactory conditions of inboard and outboard seals.

11.2.2 Shaft Extension Surveys – Extension Types

11.2.2.1 *Extension up to 2.5 years*

.1 In addition to the pre-requisites listed in 11.2.1.2.1, the Chief Engineer is to confirm that the shafting arrangement is in good working condition, for extension up to 2.5 years to be applied.

.2 The survey is to consist of:

- Checking and recording the bearing wear down measurements, as far as practicable;
- Visual inspection of all accessible parts of the shafting system;
- Verification that the propeller is free of damages which may cause the propeller to be out of balance;
- Verification of the effectiveness of inboard seal and outboard seals.

11.2.2.2 *Extension up to 1 year*

.1 In addition to the pre-requisites listed in 11.2.2.1.1, the previous wear down and/ or clearance recordings are also to be reviewed, for extension up to 1 year to be applied.

.2 The survey is to consist of:

- Visual inspection of all accessible parts of the shafting system;
- Verification that the propeller is free of damage which may cause the propeller to be out of balance;
- Verification of the effectiveness of inboard seal and outboard seals.

11.2.2.3 *Extension up to 3 months*

.1 The pre-requisites listed in 11.2.2.2.1 above are to be verified and found satisfactory for extension up to 3 months to be applied.

.2 The survey is to consist of:

- Visual inspection of all accessible parts of the shafting system;

- Verification of the effectiveness of the inboard seal.

11.2.3 Methods for oil lubricated shafts and fresh water lubricated shafts (closed loop systems) and shaft survey intervals.

Details of the applicable methods for flanged propeller connection, keyless propeller connection and keyed propeller connection and survey intervals are listed in Table 11.2.3.The types of survey extensions applicable, are also listed in Table 11.2.3.

Table 11.2.3 Survey Intervals (Closed Systems)

Oil Lubricated [Survey Notation SH (OL)]			
	Flanged Propeller Coupling	Keyless Propeller Coupling	Keyed Propeller Coupling[c]
Every five years[a]	Method 1 or Method 2 or Method 3	Method 1 or Method 2 or Method 3[d]	Method 1 or Method 2
Extension 2.5 Y[b]	Yes[e]	Yes[e]	Yes[e]
Extension 1 Y[b]	Yes[f]	Yes[f]	Yes[f]
Extension 3 M[d]	Yes[g]	Yes[g]	Yes[g]
Fresh Water Lubricated [Survey Notation SH (FW-C)]			
	Flanged Propeller Coupling	Keyless Propeller Coupling	Keyed Propeller Coupling[c]
Every five years[a]	Method 1[h] or Method 2 or Method 3	Method 1[h] or Method 2 or Method 3	Method 1[h] or Method 2
Extension 2.5 Y[b]	Yes[e]	Yes[e]	Yes[e]
Extension 1 Y[b]	Yes[f]	Yes[f]	Yes[f]
Extension 3 M[d]	Yes[g]	Yes[g]	Yes[g]

General Notes :

For surveys (Method 1, or Method 2, or Method 3) completed within 3 months before the shaft survey due date, the next period is to start from the shaft survey due date.

The extension survey is normally to be carried out within 1 month of the shaft survey due date and the extension counts from the shaft survey due date. If the extension survey is carried out more than 1 month prior to the shaft survey due date, then the period of extension counts from the date on which the extension survey was completed.

Methods 1, 2 & 3 are described in 11.2.1.1, 11.2.1.2 and 11.2.1.3 respectively. The pre-requisites for each Method are to be satisfactorily verified, prior surveys.

Survey methods 1, 2 and 3 would normally require drydocking of the vessel. Extension surveys may be carried out without dry-docking by in water surveys.

Notes to Table 11.2.3

a) Unless an Extension type (Extension 2.5 Y, Extension 1 Y, Extension 3 M) is applied in between.

b) Only one Extension type can be applied in between of two Methods (Extension 2.5 Y, or Extension 1 Y) except for what concerns the Extension 3 M (see further note g).

c) Method 3 is not allowed.

d) Maximum of two consecutive Method 3 surveys. The maximum interval between two surveys carried out according to Method 1 or Method 2 is not to exceed 15 years, except in the case when one extension for no more than three months is granted.

e) No more than one extension can be granted. No further extension of other type can be granted.

f) No more than two consecutive "one year extensions" can be granted. No further extension of other type can be granted.

g) No more than one "three months extension" can be granted. In the event an additional extension is requested, the requirements of "one year extension" are to be carried out and the shaft survey due date prior to the previous extension is to be extended for a maximum of one year.

h) The maximum interval between two surveys carried out according to Method 1 is not to be more than 15 years. An extension for no more than three months can be granted.

11.3 Water Lubricated Shafts (Open Systems)

11.3.1 Shaft Survey Methods

11.3.1.1 **METHOD 4**

The survey is to consist of

- Drawing the shaft and examining the entire shaft (including liners, corrosion protection system and stress reducing features, where provided), inboard seal system and bearings.

- For keyed and keyless connections:

- removing the propeller to expose the forward end of the taper,

- performing a non-destructive examination (NDE) by an approved surface crack detection method all around the shaft in way of the forward portion of the taper section, including the keyway (if fitted). For shaft provided with liners the NDE is to be extended to the after edge of the liner

- For flanged connection:

- Whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul, repairs or when deemed necessary by the surveyor, the coupling bolts and flange radius are to be examined by means of an approved surface crack detection method.

- Checking and recording the bearing clearances.

- Verification that the propeller is free of damage which may cause the propeller to be out of balance.

- Verification of the satisfactory conditions of inboard seal during re-installation of the shaft and propeller.

11.3.2 Shaft Extension Surveys – Extension Types

11.3.2.1 *Extension up to 1 year*

.1 Pre-requisites to be verified and found satisfactory in order to apply extension up to 1 year are as follows:

- Review of the previous clearance recordings;

- Service records;

- Verification that there are no repairs by grinding or welding of shaft and/or propeller;

- Confirmation from the Chief Engineer that the shafting arrangement is in good working condition.

.2 The survey is to consist of:

- Visual Inspection of all accessible parts of the shafting system;

- Verification that the propeller is free of damages which may cause the propeller to be out of balance;

- Checking and recording the clearances of bearing;

- Verification of the effectiveness of the inboard seal.

11.3.2.2 *Extension up to 3 months*

.1 The pre-requisites listed in 11.3.2.1.1 are to be satisfactorily verified, for extension up to 3 months to be applied.

.2 The survey is to consist of:

- Visual Inspection of all accessible parts of the shafting system;

- Verification that the propeller is free of damage which may cause the propeller to be out of balance;

- Verification of the effectiveness of the inboard seal.

11.3.3 Methods for water lubricated shafts (open loop systems) and shaft survey intervals, along with applicable details are given in Table 11.3.3.

11.3.3.1 For single shaft operating exclusively in fresh water, single shaft provided with adequate means of corrosion protection, corrosion resistant shafts and multiple shaft arrangements; survey intervals up to 5 years may be allowed. Applicable details along with maximum permissible survey intervals are given in Table 11.3.3.

11.3.3.2 Shaft arrangements, other than the configurations listed in 11.3.3.1, are to be surveyed according to Method 4, every 3 years. Applicable details along with maximum permissible survey intervals are also given in Table11.3.3.

Table 11.3.3 Survey Intervals (Open Systems)

Single shaft operating exclusively in fresh water [Survey Notation SH (S-FW-O)] **Single shaft provided with adequate means of corrosion protection, single corrosion resistant shaft** [Survey Notation SH (S-CP-O)] **All kinds of multiple shaft configurations** [Survey Notation SH (M-O)]		**Other Shaft Configurations** [Survey Notation SH (S-O)]	
All kinds of propeller couplings[d]			
Every five years[a]	Method 4	Every three years[a]	Method 4
Extension 1 Y	Yes[b]	Extension 1 Y	Yes[b]
Extension 3 M	Yes[c]	Extension 3 M	Yes[c]

General Notes :

For surveys (Method 4) completed within 3 months before the shaft survey due date, the next period will start from the shaft survey due date.

The extension survey is to be normally carried out within 1 month of the shaft survey due date and the extension counts from the shaft survey due date. If the extension survey is carried out more than 1 month prior to the shaft survey due date, then the period of extension is to count from the date on which the extension survey was completed.

Method 4 is described in 11.3.1.1. The pre-requisites for the Method are to be satisfactorily verified, prior survey.

Survey method 4 would normally require dry docking of the vessel. Extension surveys may be carried out without dry-docking by in water surveys.

In case of multiple shaft configurations, if there is a failure to one shaft system, vessel is to be dry-docked for carrying out surveys of all shaft systems, and repairs as necessary.

Notes :

a) Unless an Extension type (Extension 1 Y, Extension 3 M) is applied in between.

b) No more than one extension can be granted. No further extension, of other type, can be granted.

c) No more than one extension can be granted. In the event an additional extension is requested the requirements of the one year extension are to be carried out and the shaft survey due date prior to the previous extension is to be extended for a maximum of one year.

d) For keyless propeller connections the maximum interval between two consecutive dismantling and verifications of the shaft cone by means of non-destructive examination (NDE) is not to exceed 15 years

11.4 Steerable and azimuth thrusters

The survey is to normally comprise of examination of the following:

a) Exposed parts including attachment to the hull.

b) The following items upon removal of propeller:

   - propeller shaft threaded end and nut;
   - cone, key and keyway including examination by an efficient crack detection method of fore part of the shaft cone;
   - sealing glands.

c) Lubricating oil analysis (to include wear particle analysis) records to detect possible wear of internal gears and bearings.

d) Internal gears and control gears as far as practicable through hand holes or limited opening of controlling device.

If the above checks are not satisfactory, complete dismantling of the internal parts may be required.

11.5 Vertical axis propellers

The survey is to normally comprise of examination of the following:

a) Exposed parts.

b) Tightness of the oil glands and the backlash of the gears from outside by action on the blades.

c) Gears, as far as practicable through hand holes and observation ports.

d) Control gear for proper functioning.

e) Lubricating oil analysis (to include wear particle analysis) records to detect possible wear of internal gears and bearings.

If the above checks are not satisfactory, complete dismantling of the internal parts may be required.

11.6 Water jet systems

The survey is to normally comprise of examination of the following:

a) Impeller, shaft and bearing clearances.

b) Sealing glands.

c) Nozzle assembly.

d) Control and reversing gear.

e) Suction grids.

If the above checks are not satisfactory further dismantling may be required.

11.7 Controllable pitch propellers

Where controllable pitch propellers are fitted, in addition to the survey requirements of the shafts, the working parts and control gear are to be opened up sufficiently to enable Surveyors to examine them at each shaft survey. The survey is to include the following:

a) Analysis of hydraulic oil including wear particle analysis.

b) Propeller blades and hub including crack detection of blade root, flange and blade securing arrangements.

c) Examination of seals, carrier bearings, crank pin ring, fillets, blade openings in the boss and blade bolts, upon removal of at lest one blade.

d) Examination of distribution box seal and bearings.

e) Verification upon re-assembly of, servomechanism and hydraulic test of hub and hydraulic piping including pitch controls together with limit stops.

Section 12

Surveys of Inert Gas Systems

12.1 General

12.1.1 Inert gas systems installed on board ships intended for the carriage of oil or liquid chemicals in bulk or liquefied gases are to be surveyed periodically as detailed in Sec.1 of this Chapter.

12.2 Annual surveys

12.2.1 Following are to be examined at each Annual Survey:

a) external examination of the condition of all piping and components for signs of corrosion or gas/effluent leakage.

b) verification of the proper operation of both inert gas blowers.

c) checking the operation of scrubber room ventilation system.

d) checking of deck water seal for automatic filling and draining and checking for the presence of water carry over and checking the condition of non-return valve.

e) examination of the operation of all remotely or automatically operated valves and, in particular, the flue gas isolating valve(s).

f) checking the interlocking feature of soot blowers.

g) checking that the gas pressure regulation valve automatically closes when the inert gas blowers are secured.

h) checking as far as practicable, the following alarms and safety devices of the inert gas systems using simulated conditions where necessary:

- high oxygen content of gas in the inert gas main;
- low gas pressure in the inert gas main;
- low pressure in the supply to the deck water seal;
- high temperature of gas in the inert gas main;
- low water pressure to the scrubber;
- accuracy of portable and fixed oxygen measuring equipment by means of calibration gas;
- high water level in scrubber;
- failure of the inert gas blowers;
- failure of the power supply to the automatic control system for the gas regulating valve and to the instrumentation for continuous indication and permanent recording of pressure and oxygen content in the inert gas main;
- high pressure of gas in the inert gas main.
- Surveys carried out by the National Authority of the country in which the ship is registered would normally be accepted as meeting these requirements, at the discretion of the Surveyor.

12.2.2 Checking when practicable, the proper operation of the inert gas system on completion of the checks listed in 12.2.1 h).

12.3 Special surveys

12.3.1 At each Special Survey of the inert gas system, the inert gas generator, scrubber and blower are to be opened out as considered necessary and examined. Gas distribution lines and shut off valves, including soot blower interlocking devices are to be examined as considered necessary. The deck seal and non-return valve is to be examined. Cooling water systems including the effluent piping and overboard discharge from scrubbers are to be examined. All automatic shut down devices and alarms are to be tested. The complete installation is to be tested under working conditions on completion of Survey.

12.3.2 When, at the request of an Owner, it has been agreed by IRS that Complete Survey of the inert gas system may be carried out on the continuous basis, the various items of the system are to be opened up for survey in rotation, so far as practicable, to ensure that the interval between consecutive examinations of each item will not exceed five years. In general one-fifth of the machinery is to be examined each year.

12.3.3 If any examination during Continuous Survey reveals defects, further parts are to be opened up and examined as considered necessary by the Surveyor, and the defects are to be made good to his satisfaction.

Section 13

Surveys of Vessels with Refrigerated Cargo Installations

13.1 General

13.1.1 Refrigerated Cargo Installation, on ships which have been assigned the character HY, are to be surveyed periodically as indicated in Sec.1 of this Chapter.

13.1.2 Where a Refrigerated Cargo Installation holds dual classification with IRS, additional Periodical Survey requirements, if any, of the corresponding Society would also be applicable.

13.2 Periodical surveys

13.2.1 A Special Survey is to be held at 5 yearly intervals. When due to special circumstances a Special Survey is commenced prior to its due date, the Survey is to be completed within a period not exceeding 9 months and not later than the expiry date of the classification certificate including any postponement that may be granted by IRS.

13.2.2 If a vessel at the time classification certificate expires is not in a port in which it is to be surveyed, IRS may upon Owners request extend the validity of the classification certificate for a period not exceeding 3 months. Such requests will only be considered to enable the vessel to complete its voyage to the port of survey and only in cases where it is considered proper and reasonable to do so.

13.3 Continuous special survey of refrigerating installation

13.3.1 At the request of the Owners and upon receipt of a satisfactory proposed arrangement, IRS may give consideration to a system of Continuous Survey of refrigerating installation (CS HY) being carried out whereby the requirements of Special Surveys as detailed in 13.5 and 13.6 are completed within a five year period. In such case the various items of machinery should be opened out for Survey in rotation, so far as practicable, to ensure that the interval between consecutive examination of each item does not exceed five years and it is expected that approximately an equal proportion of the surveyable items would be subjected to Survey each year.

13.3.2 In case any defects are revealed during these examinations, further parts may have to be opened up as considered necessary by the Surveyor.

13.4 Annual survey requirements

13.4.1 Log Books or other records are to be examined to ascertain that the installation has been working satisfactorily. Any indications of breakdowns or defects, during the previous 12 months, are to be noted and reported. Whenever possible, an examination of the refrigerating plant is to be made upon arrival of the ship at the port of discharge before refrigerated cargo is unloaded.

13.4.2 Refrigerated chambers/holds are to be examined after careful cleaning. A detailed examination is to be made of these spaces. For this purpose, removable panels and covers are to be removed and if appropriate, spot checks of the insulation are to be carried out for condition and shrinkage. If there is trace of damp or leakage of the insulation from whatever source (fuel tank, pipe work, pipe coils, scuppers, etc.) or any trace of deterioration in the insulation or its lining, of the air ducts or air coolers, a more thorough examination is to be made and necessary measures taken to correct the defects thus ascertained.

13.4.3 Where the cargo is refrigerated by circulating air, the proper air tightness of the air ducts, air cooler casings, hatch covers, doors, butterfly dampers in ventilation ducts is to be checked. The insulation of the lining joints should also be carefully checked.

13.4.4 The bilges are to be cleaned and suction pipes, sounding pipes and scupper non-return valves examined. The Surveyor should satisfy himself that all scuppers draining the chambers and cooler trays are in good working order.

13.4.5 Air cooler coils, cooling grids and valves are to be examined and the Surveyor should satisfy himself that no pipe is partially or completely choked and that the valves are in good working order.

13.4.6 Brine coils are to be examined whilst under a pressure of 1.5 times working pressure or 3 bar whichever is greater.

13.4.7 Primary refrigerant cooler coils and grids are to be examined whilst under the refrigerant pressure prevailing in the system at the time of the Survey with the plant at rest and the regulating valves opened just sufficient to obtain an approximate balance of pressure throughout the system and to avoid accumulation of liquid in the coils or grids.

13.4.8 The shells of condensers, evaporators, separators, receivers, and other pressure vessels are to be examined as far as practicable. Any evidence of excessive corrosion of water end covers of "shell and tube" and "double-pipe" type condensers is to be investigated.

13.4.9 Primary refrigerant gas and liquid pipes, condenser cooling water piping and valves are to be examined as far as possible.

13.4.10 Any evidence of dampness or deterioration of the insulation which could lead to external corrosion of the vessels or other parts mentioned, is to be investigated and necessary measures are to be taken to correct the defects thus ascertained.

13.4.11 A general examination is to be made of the fans, their motors, control gear and the insulation resistance is to be measured. The insulation resistance is not to be less than 100,000 ohms. The generating plant supplying electric power is to be examined generally with a view to ascertaining that the plant is being efficiently maintained.

13.4.12 The thermometers for measuring the chamber air suction and air delivery temperatures are to be examined. If repairs and renewals are carried out, the thermometers are afterwards to be checked for accuracy.

13.4.13 A Survey book or other permanent record is to be kept on board the ship to show the date of examination of various parts. This is to be available to the Surveyor at all times and is to be signed by the Surveyor on each occasion after the Survey.

13.5 Requirements of first special survey

13.5.1 Each reciprocating compressor, including those provided for sub- cooling the primary refrigerant, is to be opened up. Cylinder bores, pistons, piston rods, connecting rods, valves and seats, glands, relief devices, suction filters and lubricating arrangements are to be examined. Crankshafts are to be examined, but crankcase glands and the lower halves of main bearings need not be exposed if the Surveyor is satisfied as to alignment and wear.

13.5.2 For screw-type compressors, the period before opening up may be extended to 6 years or 25000 running hours, whichever is the earlier.

13.5.3 Where there is a programme of replacement instead of Surveys on board, alternative Survey arrangements will be considered. Each case will be given individual consideration.

13.5.4 Refrigerant condenser cooling water pumps, including standby pump(s) which may be used on other services, are to be opened up and their working parts exposed.

13.5.5 Brine and primary refrigerant pumps are to be opened up and their working parts exposed. Special consideration will be given to Survey requirements for primary refrigerant pumps of the hermetically sealed type.

13.5.6 The water end covers of "shell and tube" and "double-pipe" type condensers are to be removed for examination of the tubes, tube plates and covers.

13.5.7 The shells and connections of "shell-and-tube" and "double-pipe" type condensers and evaporators, separators, receivers, driers, filters and other pressure vessels, and the coil terminals of "coil-in-casing" type condensers and evaporators, are to be examined as far as practicable.

13.5.8 In the case of pressure vessels covered by insulation, any evidence of dampness or deterioration of the insulation which could lead to external corrosion of the vessels or their connections is to be investigated.

13.5.9 Sufficient insulation is to be stripped from insulated pressure vessels to allow the condition of the vessels and their connections to be ascertained. Care is to be taken that in replacement of the insulation, the vapour sealing of the outer covering is made good.

13.5.10 Sufficient insulation is to be stripped from pipes carrying the refrigerant at various points of the system both outside and inside the insulated chambers to permit the condition of the pipes to be ascertained. Sections of piping exposed are to include locations where lengths of piping have been connected by screwed couplings or butt welding. Care is to be taken that when ungalvanized portions of the piping in way of joints have been exposed they be suitably coated and taped, after pressure testing, to prevent corrosion. On replacement of the insulation, the vapour sealing of the outer covering is to be made good.

13.5.11 The Surveyor is to satisfy himself that all pressure relief valves and/or safety discs throughout the refrigerating plant are in good order. However, no attempt is to be made to test primary refrigerant pressure relief valves on board ship.

13.5.12 Sea connections to refrigerant condensers cooling water pumps are to be opened up on the occasion of the hull and/or main machinery Special Survey.

13.5.13 The electric motors driving refrigerant compressors, pumps and fans, together with their control gear and cables, are to have their insulation resistance tested and this is to be not less than100000 ohms between all insulated circuits and earth. The installation may be subdivided to any desired extent by opening switches, removing fuses or disconnecting appliances for the purpose of this test.

13.5.14 The fittings on switchboards and Section boards are to be examined, and over-current protective devices and fuses are to be inspected to verify that they provide suitable protection for their respective circuits.

13.5.15 Any arrangements fitted to disconnect automatically the excess non- essential load when the electrical generators are overloaded are to be examined to ascertain that the circuits for cargo refrigerating machinery are included in the last group to be disconnected.

13.5.16 All automatic controls and alarms are to be tested.

13.5.17 Sufficient air trunking and insulation lining is to be stripped from the chamber's overhead and vertical surfaces to allow the condition of the insulation, insulation linings, grounds, supports, hangers and fixtures which support the insulation, grids, meat rails, etc., to be ascertained. Care is to be taken that on replacement the ducts and linings are sealed against air blowing into the insulation, or against moisture ingress from refrigerated cell or space atmosphere.

13.5.18 Sufficient tank top insulation is to be stripped to allow the condition of the grounds and inner insulation lining to be ascertained.

13.5.19 Due consideration is to be given to the type of insulation used in the holds and chambers when determining the amount of insulation lining to be removed as detailed in 13.5.17 and 13.5.18. Where organic foam insulants have been used, including foamed "in situ", or other insulants in slab form, the Surveyor should use his discretion regarding the removal of linings if he is able to satisfy himself that the condition of the insulation is good by means of test bore holes.

13.5.20 Under normal circumstances, the condition of hold and chamber insulation, grounds, etc., can be ascertained when the Special Survey of the ship's steel structure is being held.

13.5.21 Arrangements made for defrosting air coolers, and for draining condensate from trays below coolers, are to be examined to ascertain that they are in working order.

13.5.22 Any air refreshing arrangements are to be examined.

13.6 Subsequent special surveys

13.6.1 In addition to the requirements for first Special Survey the following items, as mentioned in Table 13.6.1, are to be tested and examined.

13.7 Loading port surveys

13.7.1 Where the Owner or his authorised representative requests for a Loading Port Survey, a Survey as detailed below is to be carried out at the Loading Port.

13.7.2 In the case of ships engaged on voyages of less than two months duration, a loading port certificate will be considered as valid for two months, provided the cargoes carried are of such a nature as not to damage the insulation or appliances in the insulated chambers, nor to affect by taint or mould the refrigerated cargoes loaded during that period.

13.7.3 If a vessel loads at more than one port, Loading Port Survey at the first Loading Port would only be required provided all the chambers which are intended to be loaded with refrigerated cargo during the voyage are offered for examination and no general cargo is subsequently loaded in these chambers prior to loading of refrigerated cargo.

13.7.4 The refrigerated cargo spaces are to be examined in an empty state prior to loading the cargo. The Surveyor is to satisfy himself that the spaces are clean and free from odour which may adversely affect the cargo to be loaded.

The brine or other refrigerant pipe grids, cooler coils and connections should show no trace of leakage. The Surveyor should also satisfy himself that the fixed cargo battens on the vertical surfaces are in good order, that cargo gratings or dunnage battens are provided for the floors or decks and that no damage has been sustained to the insulation or its lining prior to the loading of the refrigerated cargo.

13.7.5 Any indication of defective insulation not considered to warrant immediate attention should be noted and specially reported.

13.7.6 The scuppers and bilges in the refrigerated cargo spaces are to be clean and dry and the liquid seals should be primed.

13.7.7 The Surveyor will check whether the entire refrigerated cargo installation operates satisfactorily and he will record the temperatures in the cargo spaces.

13.7.8 The proper operation of air duct couplings for connecting refrigerated containers on the ship's own refrigerating installation has to be checked. If refrigerated containers are coupled to the air ducts during the on board Survey, the tight sealing effect of the couplings is also to be checked.

13.7.9 It is to be clearly understood that the certificate issued for the carrying out of a Loading Port Survey is not in respect of the cargo to be loaded or the manner in which it is to be stowed.

Table 13.6.1 : The requirements of special surveys

Item	Dichlorodifluoro-methane (R12)	Ammonia (NH_3) or Monochlorodifluoro-methane R22)	Carbondioxide (CO_2)
"Shell and tube" type gas condensers or gas evaporators (brine coolers) (primary refrigerant in the shell)	7 bar	14 bar	-
	Water or brine end covers to be removed and shell pneumatically tested with the refrigerant or air or a mixture of inert gas and refrigerant to the above pressures		
"Coil in casing" type gas condensers	17 bar	70 bar	140 bar
	Where it is impracticable to remove the coils they may be examined and tested in place		
"Coil in casing" type gas evaporators (brine coolers)	14 bar	35 bar	105 bar
	Where it is impracticable to remove the coils they may be examined and tested in place		
Primary refrigerant chamber grids or air cooler coils	7 bar	10 bar	70 bar
"Shell and tube" type gas evaporators (brine coolers) (brine is in the shell)	Primary refrigerant end covers are to be removed and tested		
	Shell to be hydraulically tested to twice the design pressure but not less than 3 bar		

Section 14

Planned Maintenance System

14.1 General

14.1.1 An approved Planned Maintenance System on board a ship may be accepted in lieu of the regular surveys by IRS Surveyors on CSM basis provided the requirements of this section are complied with.

Any item not covered by PMS is to be surveyed and credited in the usual way. In general the intervals for PMS is not to exceed those specified for CSM survey. PMS is to be programmed and maintained by a computerised system.

14.1.2 A vessel complying with the requirements of section will be assigned the PMS survey notation.

14.1.3 The survey system (PMS) is to be approved by IRS before being implemented. When the system is implemented machinery inspection may be based on calendar or running hours calling for items to be opened for inspection and overhaul at specified periods, or the machinery may be monitored for condition and performance whereby items need only be opened for examination when readings indicate a deterioration. Schemes could be made up of a combination of two or more methods of maintenance control, such as:

- A switchboard is surveyed based on regular 5 yearly intervals.

- A diesel engine is surveyed based on running hours.

- A lubricating oil pump is surveyed based on calendar interval.

- A steam turbine driven pump may be surveyed based on condition monitoring.

14.1.4 When certain machinery and components are approved under PMS for condition monitoring and when their condition and performance is within acceptable limits, no overhaul is necessary, unless otherwise specified by the manufacturer.

14.1.5 Other items of machinery and components, which are not subjected to an approved condition monitoring system and part of PMS are required to be surveyed at intervals not greater than those specified for CSM.

14.1.6 Chief Engineer of the vessel will be responsible and in-charge of PMS and is to be approved by IRS as per Pt.1, Ch.2, 1.4.3.

14.1.7 The survey of machinery and components (defined at 14.2) & covered by the PMS may be carried out by the Chief Engineer. Survey of machinery and components defined in 14.3 is not eligible to be surveyed by the Chief Engineer.

14.1.8 At the time of the Annual Classification Survey an audit of the planned maintenance system will be carried out to ensure that the system is being correctly operated in accordance with the conditions of approval.

14.1.9 When the annual audit is held, a confirmatory survey will be carried out for those items to be credited which have been examined by the Chief Engineer under the planned maintenance system during the preceding year.

14.2 Machinery acceptable for survey by Chief Engineers under Planned Maintenance System

14.2.1 The following machinery may be surveyed by the Chief Engineer under PMS:

- Main engine cylinder covers.
- Main engine valves and valve gears.
- Main engine cylinder liners.
- Main engine pistons and piston rods.
- Main engine connecting rods, crossheads, top end bearings, guides, gudgeon pins and bushes.
- Main engine crankshafts and bearings (multiple engine installations only).

- Main engine fuel injection pumps and fuel booster pumps.
- M.E. Scavenge pumps, blowers and air coolers.
- Main engine detuners, dampers and balancer units.
- Main engine camshaft and camshaft drive.
- Main propulsion steam turbines (casing, rotor and blading) at alternate surveys provided the monitoring defined in 14.8.1.2 is provided and vibration measurements and full power trials are carried out at the time of the survey in the presence of a Surveyor.
- M.E. driven pumps, e.g. bilge, lubricating oil, cooling water.
- Independently driven pumps and associated motors and cables where insulation resistance readings are supplied e.g. bilge, ballast, fresh water cooling, sea water cooling, lubricating oil, oil fuel transfer.
- M.E. fresh water and lubricating oil coolers.
- Low pressure heaters used in fuel oil systems of internal combustion engines
- Main and auxiliary condensers/drain coolers.
- Air compressors including their safety devices.
- Windlass and windlass machinery.
- Forced or induced draught fans.
- Auxiliary oil and steam engines including their coolers and pumps (provided the number of generating sets is such that all services essential to the propulsion and safety of the ship, also the preservation of refrigerated cargo, can be supplied when any two sets are not working. One of these sets can be overhauled while the other remains as "stand-by").
- Intermediate shafts.
- Main engine thrust bearing.

Note : In cases where torsional vibration characteristics indicate that there is no susceptibility to damage as a result of uneven firing and the condition monitoring equipment defined in 14.8.1.1 is installed, a special arrangement may be granted whereby the Chief Engineer is permitted to survey the main engine crankshafts and bearings on single engine installations provided a modified confirmatory survey is carried out by IRS Surveyors at the time of the annual audit as follows:

- Check condition-monitoring records. (See 14.8.1.1)
- Check bearing clearances where possible.
- Check for signs of wiped or broken white metal in crankcase.
- Check witness marks of shrink fits.

- Check bed plate structure inside and outside.
- Obtain Chief Engineer's statements regarding crankpins, journals and bearings.

Ships fitted with Approved Inert Gas Systems

- Scrubber units
- Blowers
- Independent gas generators.

14.3 Machinery not acceptable for Survey by Chief Engineers

- Main engine crankshaft and bearings in single engine installations where special requirements in 14.2.1 are not complied with
- Reduction/increase gearing, flexible couplings and clutches.
- Holding down bolts and chocks
- Crankcase doors, crankcase and scavenge relief devices
- Boilers and all other pressure vessels
- Boiler fuel oil heaters
- Steam pipes and starting air pipes
- Maneuvering valves and bulkhead stop valves
- Steering machinery
- Pumping arrangements for Bilge/Ballast/ Fuel Oil/Fresh Water/Sea water/Lub.Oil/ Fire
- Electrical equipment other than that defined in 14.2.1
- Propellers
- Screwshafts
- Sea connections
- M.E. controls, bridge, centralised or automatic and controls in unmanned machinery spaces
- Engine trial
- First start arrangements trial.

Ships fitted with Approved Inert Gas Systems

- All other I.G. system components not listed in 14.2.1.

14.4 System Administration

14.4.1 The Owner is to make a formal request to IRS providing the documentation and information detailed in 14.4.2 below for approval of the system.

14.4.2 The documentation and information to be submitted is to include the following:

a) A description of the system and its application onboard and organizational interface identifying the areas of responsibility ashore and the people responsible for the PMS onboard.

b) The list of items of machinery, equipment and components to be considered for inclusion in the PMS. The list is to be same in terms of description and identification with the identification system adopted by IRS.

c) Time schedules and scope of the maintenance procedures for each item listed in b), including acceptable limit conditions of the parameters to be monitored on items of opened up machinery, based on the manufacturer's recommendations or recognized standards. These are to be laid down in appropriate PMS sheets.

d) For machinery identified to be maintained under condition monitoring, maintenance and condition monitoring methods to be used, the time intervals for monitoring and maintenance of each item, the original reference data where applicable, the list and specifications of the condition monitoring equipment.

   The acceptable limits of deteriorated condition should be stated and these are to be derived from manufacturer’s recommendations, applicable severity criteria as defined in applicable Standards, or the Owners requirements when these are more severe.

e) The documentation flow and filing procedure.

This is to include a system for reporting to Owners, records to be maintained onboard and at Owner's head quarters.

f) A list of all personnel likely to be in-charge of the PMS system.

14.4.3 Computerized system requirement

14.4.3.1 The access to and updating the maintenance documentation and the maintenance program is to be permitted by the Chief Engineer or other authorized person only.

14.4.3.2 The system is to be suitably protected by suitable password access w.r.t. alterations to maintenance schedules, list of items under PMS and noting of damages.

14.4.3.3 The computerized system is to include a backup procedure, which is activated at regular intervals.

14.4.3.4 The functional applications of these computerized systems are to be approved by IRS.

14.4.4 Information to be available onboard.

a) All the documentation listed in 14.4.2, duly updated.

b) Maintenance instructions for each machinery, as applicable (supplied by the manufacturer or the shipyard).

c) The condition monitoring data including all data since last opening of the machinery and where applicable the original reference data.

d) Reference documentation (trend investigation procedures etc.).

e) The records of the maintenance performed, including conditions found, repairs and renewals carried out.

14.5 System Implementation

14.5.1 After the PMS documentation has been approved, a confirmation survey is to be carried out by IRS Surveyors.

14.5.2 Upon successful completion of the Confirmatory Survey, the PMS is considered approved and the survey notation PMS is assigned to the vessel and entered in the Register of Ships.

14.5.3 The PMS is retained throughout the class period of the vessel provided that :

a) An annual report covering the year's service is submitted to IRS detailing the list of items of machinery and components which were subjected to preventive maintenance in the period under review, together with preventive maintenance sheets, the condition monitoring data including all data since last dismantling and any changes to PMS documentation.

b) An annual audit of the PMS is carried out.

c) Any change to the PMS is submitted to IRS for approval.

14.5.4 The survey agreement for machinery according to PMS will be withdrawn by IRS if the PMS is not satisfactorily operated in terms of improperly maintained records or unsatisfactory condition of machinery or failure to observe the agreed intervals between overhauls.

14.5.5 The Owner may discontinue the PMS at any time by informing IRS in writing. In such a case the items that have been inspected under the PMS since last annual audit may be credited for IRS records at the discretion of the attending surveyor carrying out confirmatory surveys.

14.5.6 In case of sale or change of management of the ship the PMS will require to be re-approved.

14.6 System Surveys

14.6.1 **Confirmation Survey** is to be carried out by an IRS Surveyor within one year from the date of the documentation approval. The scope of this survey is to verify that :

a) The PMS is implemented as per the approved documentation and is suitable to the type and complexity of machinery and systems onboard.

b) The documentation required for the annual audit is available and the adopted system is able to produce such a report.

c) The requirements of surveys and testing for continuing the class status are complied with.

d) The shipboard personnel are familiar with the PMS procedures including documentation.

14.6.2 **Annual Audit** is to be carried out once the PMS is implemented and approved, to verify the continued compliance with the documented PMS. The annual audit is carried out in conjunction with the annual class surveys. The scope of the audit is to be as given in the following :

a) The Surveyor is to verify that the PMS is correctly operated and that all items (due for survey in the relevant period) have actually been surveyed in due time.

b) The Surveyor is to verify that the machinery has been functioning satisfactorily upon review of the maintenance and performance records since the previous survey or audit and where needed necessary measures have been taken in response to machinery operating parameters exceeding acceptable limits and that the overhaul intervals have been observed.

c) A report detailing overhaul/repairs carried out and spare parts used on items in the list of surveyable items is to be presented by the Chief Engineer. Any machinery part or component, which has been replaced by a spare due to damage, is to be retained onboard and submitted to the attending surveyor's examination.

d) The attending surveyor after verification of records on board for the identification details of the Chief Engineers who have undertaken the maintenance activity and prepared the reports given in c), for compliance with the approved PMS, and upon satisfactory general examination and confirmatory surveys will credit the items for survey.

e) Where condition monitoring equipment is in use, function tests, confirmatory inspections and random check readings are to be carried out as far as practicable and reasonable at the discretion of the surveyor. Where the condition and performance of the items are within specified approved limits, these items can be credited for survey without opening up.

f) Written reports of break down or malfunction are to be made available.

g) If the surveyor is not satisfied with results of the PMS i.e. with degree of accuracy as regards the maintenance records and/or the general condition of the machinery, a report will be forwarded to IRS recommending that the special arrangements dealing with machinery surveys be suspended.

h) Upon satisfactory completion of the annual audit the surveyor confirms the validity of the PMS by crediting the PMS Annual audit.

14.7 Damage and repairs

14.7.1 Damage to components or items of machinery covered by the PMS which may affect the class is to be reported to IRS immediately. A surveyor will attend on board, survey the damage and on the basis of the survey results decide whether condition of class is to be recommended.

14.7.2 All parts of machinery or components, which need to undergo substantial repairs, are to be surveyed by IRS before, during and after the repairs, as deemed appropriate by the attending surveyor.

14.7.3 In the case of outstanding conditions of class or records of unrepaired damage, which may affect the PMS, the relevant items are to be taken out of the PMS until the conditions of class are dealt with or the repairs are carried out.

14.8 Guidelines for machinery items surveyed on the basis of condition monitoring

14.8.1 The extent of condition based maintenance and associated monitoring of equipment; to be included in the PMS is decided by the owner. The minimum parameters to be checked in order to monitor the condition of the various machinery for which this type of maintenance is accepted are indicated in 14.8.1.1 to 14.8.1.4.

14.8.1.1 For the main propulsion diesel engine the following parameters are to be monitored.

- Shaft horse power
- Engine and shaft RPM
- Indicator diagrams (both power and injection timing), where applicable
- Fuel oil temperature and/or viscosity
- Charge air pressure
- Exhaust gas temperatures for each cylinder and before and after turbochargers
- Engine cooling system temperatures and pressures
- Engine lubricating oil system temperatures and pressures
- Turbocharger RPM and vibration
- Lubricating oil analysis data

- Crankshaft deflections
- Main bearing temperatures.

14.8.1.2 For the main and auxiliary steam turbines the following parameters are to be monitored.

- Turbine rotor/bearing vibration
- Turbine rotor axial displacement
- Shaft horsepower
- Shaft and turbine rotor RPM
- Plant performance data i.e. steam conditions at the inlet and outlet of each turbine, boiler performance data, condenser vacuum, sea temperatures.

14.8.1.3 For the auxiliary diesel engines the following parameters are to be monitored.

- Exhaust gas temperatures for each cylinder and before and after turbochargers
- Engine cooling system temperatures and pressures
- Engine lubricating oil system temperatures and pressures
- Turbocharger RPM and vibration
- Lubricating oil analysis data
- Crankshaft deflections.

14.8.1.4 For other auxiliary machinery the following parameters are to be monitored.

- Cooler inlet and outlet temperatures and efficiencies
- Inlet and outlet temperatures of heaters
- Pumps and fans vibration and performance data
- Differential pressures across filters serving essential systems.

Section 15

Surveys - Vapour Control Systems

15.1 For tankers and combination carriers with notation VCS1

15.1.1 Annual Surveys

At each annual survey, the vapour emission control system is to be generally examined for ensuring its satisfactory condition. The survey is also to include:

a) Components and piping

External examination of all components and piping, including isolating / relief valves, means of collecting and draining condensate, means for separation of vapours from non-compatible cargoes and electrical continuity / bonding arrangements.

b) Manifold isolating valve

Confirmation of the proper operation of the vapour manifold isolating valve, including manual operation.

c) Vapour connection flanges

Confirmation of the continuing effectiveness of the “lug and hole” construction of the vapour connection flange(s), or other approved means of preventing misconnection of the loading hose to the vapour collection system.

d) Hoses

Confirmation that any hose used for the conveyance of vapour are in accordance with section 2.1.2 of Pt.5, Ch.29.

e) Inert gas piping

Where inert gas distribution piping is used for vapour collection, confirmation of the continuing effectiveness of the inert gas main isolating valve(s).

f) Cargo gauging system

Correct operation of the closed cargo gauging system for each tank, which is connected to the vapour collection system. Where portable gauging devices are used, the number of devices available are to be equal to the number of tanks that can be simultaneously loaded plus two (2) additional units.

g) Cargo tank venting system

Examination of the cargo tank venting system, including flame screens, where fitted.

h) Alarms and safety devices

Verification of the satisfactory operation of the following alarms and safety devices using simulated conditions, where necessary.

- High vapour pressure in main vapour collection line(s) (not required for tank barges).
- Low vapour pressure in main vapour collection line(s) (not required for tank barges).
- Cargo tank high liquid level.
- Cargo tank overfill (high-high liquid level), where fitted.
- Loss of power to alarm system or, alternatively, failure of tank level sensor circuitry.
- Automatic shutdown system, where fitted.

i) Operation and maintenance records

Examination of the permanent records to verify the satisfactory operation and maintenance of the system. Consideration may be given by the Surveyor for crediting certain items whose satisfactory operation has been properly documented and recorded.

15.1.2 Special surveys

At each Special Survey – Machinery, the following items of the vapour emission control system are to be examined for ensuring its satisfactory condition; in addition to the requirements of annual survey in 15.1.1:

a) Valves

All valves, including cargo tank isolating valves, main vapour line cross-over valves (where fitted for vapour segregation), condensate drain valves, manifold isolating valves, pressure / vacuum relief valves and spill valves / rupture disks (where fitted as additional overfill control devices) are to be examined.

b) Gauging system

The closed gauging system, including portable gauging devices where applicable, is to be examined.

c) Alarms

The independent cargo tank overfill alarms, where fitted, are to be examined.

d) Hoses

Vapour collection system hoses are to be tested for electrical continuity or non-conductivity, as applicable.

e) Inert gas piping

Where inert gas distribution piping is used for vapour collection, deck seals or double block and bleed assemblies are to be examined.

15.2 For tankers and combination carriers with notation VCS2

15.2.1 Annual surveys

At each annual survey, in addition to the requirements of 15.1.1, the following items of the vapour emission control system are to be examined for ensuring its satisfactory condition.

a) Detonation flame arrester

Confirmation that the detonation flame arrester (where fitted) is in satisfactory condition.

b) Vapour manifold

Confirmation that a means of electrical insulation (insulating flange or non-conductive hose, etc.) is provided for the vapour manifold connection.

c) Fixed oxygen analyzer

Confirmation of the accuracy of the fixed oxygen analyzer (required to be fitted within 3 [m] (10 feet) of the vessel's vapour manifold connection) by means of a calibration gas.

d) Vapour blowers / compressors

General examination of any devices (such as compressors or blowers) used to increase the vapour flow rate.

15.2.2 Special surveys

At each Special Survey – Machinery, in addition to the requirements of 15.1.2 and 15.2.1, the following items of the vapour emission control system are to be examined for ensuring its satisfactory condition:

a) Vapour Blowers / Compressors and detonation flame arresters

Vapour blowers / compressors and detonation flame arresters, where fitted, are to be examined, including isolating and relief valves, as applicable.

Section 16

Surveys of Thermal Oil Heating Systems

16.1 General

16.1.1 Thermal Oil Heating systems are to be surveyed at intervals specified in Sec.1, Table 1.1.1 of this Chapter.

16.1.2 At each Survey, the following components are to be examined as applicable.

- Oil fired thermal oil heater/s and Economiser/s are to be examined externally including the heat exchanger coils, insulation and fuel oil burning arrangement
- Circulating pumps
- Dump cooler
- Piping arrangement including control valves and insulation
- Expansion tank and temperature blocking pipe
- Alarms and safety devices
- Thermal oil (analysis results).

16.2 Oil fired thermal oil heater and Economiser

16.2.1 These are to be examined externally for condition of the insulation, cleanliness and their attachment to the ship's structure.

16.2.2 Heat exchanger coils are to be examined for any signs of overheating or corrosion and that they are in a state to ensure proper heat exchange.

16.2.3 Heat exchanger coils are to be subjected to a leakage test, at working pressure and with working fluid.

16.2.4 All mountings are to examined externally and internally, if considered necessary by the surveyor.

16.2.5 Fuel oil burning arrangements are to be examined for proper operation including operation of safety cut-outs.

16.3 Circulating pumps

16.3.1 Circulating pumps are to be examined externally and internally, if considered necessary by the surveyor. The pumps are to be examined for proper operation including automatic change over.

16.4 Dump cooler

16.4.1 Dump coolers are to be examined internally and externally including pressure relief devices.

16.5 Piping arrangement

16.5.1 Complete piping arrangement is to be externally examined including condition of insulation and tested for any leaks.

16.5.2 Pipe fittings and valves are to be examined externally and internally, if considered necessary by the surveyor.

16.6 Expansion tank

16.6.1 Expansion tank including associated save-alls is to be visually examined.

16.6.2 Arrangement to limit the temperature of thermal oil in the expansion tanks (in open vent systems) such as 'Temperature Blocking Pipe" are to be examined for proper operation.

16.6.3 De-aeration arrangement and vent is to be examined for proper operation.

16.7 Alarms and safety devices

16.7.1 Following alarms and safety devices are to be tested:

- Thermal oil high temperature alarm and safety cut out (both in Oil fired heater and Economiser)
- Minimum flow control device
- Minimum flow control alarm and safety cut out (both in Oil fired heater and Economiser)
- Flue gas high temperature alarm and safety cut out (both in Oil fired heater and Economiser)
- Thermal oil leakage alarm and safety cut out (both in Oil fired heater and Economiser)
- Expansion tank low level and low-low level alarm and safety cut out
- Fire Extinguishing arrangements.

16.8 Thermal oil analysis

16.8.1 Thermal oil is to be analysed at regular intervals – atleast annually.

16.8.2 The thermal oil shall be free from harmful contaminants and signs of oxidation or deterioration.

16.9 System operation test

16.9.1 On completion of survey the entire system is to be examined under working conditions with particular attention to signs of leakage and functioning of control and safety devices.

16.10 Repairs

16.10.1 Any defects to alarms and safety devices the proper operation of which may pose a fire risk are to be promptly repaired to the satisfaction of the surveyor.

16.10.2 When repairs or renewals are carried out to system parts or components, these are to be subjected to a pressure test to 1.5 times the working pressure, prior to putting them into service.

Section 17

Surveys of External Fire Fighting Systems

17.1 General

17.1.1 External Fire Fighting Systems on ships assigned with class notations **Agni 1, Agni 2** or **Agni 3** are to be surveyed at intervals specified in Sec. 1 Table 1.1.2 of this chapter.

17.2 Annual survey

17.2.1 The annual survey is to consist of general examination / verification of the items indicated in 17.2.2 to 17.2.7.

17.2.2 Hull

General examination of:

- Maneuvering arrangements including side thrusters and power management system, where fitted
- Floodlights.

17.2.3 Self Protection of the Vessel

Agni 1 :

- General examination and functional verification of fixed water-spraying system.

Agni 2 & Agni 3 :

- General examination of dead lights and external steel shutters
- General examination / functional verification of insulation / water spray system, where fitted.

17.2.4 Water monitors and controls

- General examination of water monitors and their securing arrangements
- Functional verification of water monitors
- General examination and functional verification of remote and local/manual controls.

Additional for Agni 3:

- General examination of foam monitors, foam concentrate tank and associated pumping and piping arrangements including their securing arrangements
- Condition of foam concentrate
- Functional test of the foam monitors
- General examination and functional verification of remote and local/manual controls.

17.2.5 Pumping and piping

- General examination of fire pumps and water spray pumps, associated piping from sea inlets to monitors and required instru-mentation.
- Examination and test of water spray piping over pressure preventing arrangement, where fire pumps also supply to water spray piping.
- Verification of arrangement for prevention of overheating of fire pumps at low delivery rates.

17.2.6 Portable fire fighting equipment

– General examination of hose stations and fire hydrants.
– Ensuring ready availability of hoses and nozzles for the hose stations and their condition.
– Examination of pressure reducing arrangement at hose stations.

Additional for Agni 2 & Agni 3:

– Examination of portable high expansion foam generator including condition of the foam forming liquid.

17.2.7 Fireman's Outfits

– Ensuring ready availability and condition of fireman's outfit including self contained breathing apparatus with spare air bottle.
– General examination of compressor for recharging air bottles.

17.3 Special survey

17.3.1 In addition to the requirements for annual survey the following need to be examined at each special survey.

17.3.2 Internal examination and testing of the following:

– Fire and water spray pumps
– Fire and water spray pump prime movers
– One section of fire and water spray piping to assess the condition of corrosion prevention measures
– Electrical equipment associated with the external fire fighting systems
– Foam tank to the extent possible.

Section 18

Surveys of Diving Systems

18.1 General

18.1.1 Survey requirements for diving systems permanently installed on diving support vessels, stand-alone diving systems and diving systems temporarily installed on diving support vessels are covered in the succeeding paragraphs.

18.1.2 Requirements for initial survey and classification of diving systems are laid down in Pt. 5, Ch. 26, Sec. 3.

18.1.3 The surveyor may require assistance of technically qualified personnel during surveys and repairs. Assistance may be required for the following:

- Life supports systems and monitoring equipment

- Hyperbaric Systems

- Electronic equipment and communication facilities

- Emergency operations after system malfunction due to following:

    - Failure of components;

    - Loss of breathing gas pressure;

    - Loss of power; etc.

18.1.4 All diving equipment/ systems and hyperbaric facilities are required to be maintained in conditions for which they were approved and installed.

18.1.5 A log book is to be maintained by responsible personnel detailing the dive depths, dates and times, dive durations and other details. The log book is to contain maintenance records based on inspections and checks by the crew/ other specialized personnel. Inspection procedures and check lists are also to be part of the log book. The log book is to be available for verification by the Surveyor.

18.2 Annual Surveys

18.2.1 Annual Surveys of the hull, machinery and equipment are to be made within three months either way of anniversary date each year.

18.2.2 The Surveyor is to review the Operating and Maintenance Manuals, operational and maintenance records, log books including all recorded malfunctions or repairs carried out since the last survey. Summarized procedures for normal and emergency operations are to be verified on board. The Surveyor is to record the date of last use and the extent of use of the facilities since last survey.

The Annual Survey is to include surveys/ examination/ verification of the following, as applicable:

18.2.2.1 Pressure Equipment

.1 Pressure Vessels for Human Occupancy

- Structural integrity and corrosion status of chambers and bell are to be examined by internal and external survey. Special attention is to be paid to bilges (especially floor plating contact with shell), equipment locks, location of battery packs etc. for damage and possible corrosion. Examination with NDE may be carried out, as necessary. Condition of external anodes (if fitted) is to be reviewed;

- Shell penetrations are to be examined with special attention to hot water penetrations for sign of corrosion;

- External fairings are to be removed as far as practicable to provide better access to the entire surface of the pressure boundaries. Removal of protective coatings and insulation is not required unless deterioration or trace of rust or corrosion is evident or as otherwise required by the Surveyor for inspection or NDE;

- Careful examination of doors, safe locking mechanisms, appendages, attachments, framework, sealing surfaces, supporting structures for chambers and systems, bunk supports, insulation, paintwork; etc. Presence of safe locking mechanisms is to be checked on all hatches and function tested with the relevant chamber under pressure;

- The windows/ viewports are to be examined for de-colouration, possible deterioration, signs of damage, cracks or scratches; integrity of sealing arrangement and protective shield. Windows exceeding 10 years of age are normally to be replaced;

- Adequacy of over pressure-relief valve and alarm;

- Function testing of Built in Breathing Systems (BIBS) in chambers, bells and HES.

.2 Gas Storage & Pressure Vessels in Supply and Return Lines

- Provision of hazard warning signs, Colour coding, marking and stamping of testing date on cylinders and pressure vessels is to be verified;

- Structural integrity and corrosion status of gas containers and pressure vessels is to be inspected, with NDE, if necessary. Attachments and framework, supporting steelwork are to be examined for signs of corrosion;

- In the case of gas storage compartments, high/ low Oxygen alarms fitted external to the door and in repeated position(s) are to be verified.

.3 Pumps and Compressors

- Verification that maintenance of equipment is being carried out in accordance with manufacturer’s instructions;

- Quality of breathing air and gas to be verified by specialist/ competent agency;

- Verification of solenoid switches for auto-stopping facility of compressors on overheating.

.4 System components including piping, umbilicals, hoses, valves, filters etc

- System cleanliness is to be examined by visual survey and checked for possible contamination;

- Verification of any possible chafing/ twisting of umbilicals and leaks in gas piping or in distribution boxes. Proof of pressure test of the system components by crew is to be verified.

18.2.2.2 Controls

.1 Gas Supply and Distribution

- System cleanliness to be examined by visual survey and checked for possible contamination by grease, oil, etc;

- Function test of gas-regeneration units and Oxygen make-up system to be carried out;

- Arrangements for each diver's gas supply line are to be confirmed such that if one fails, the failure does not interfere with another diver's supply.

.2 Depth / Pressure Controls

- Calibration of internal gauges, external gauges, depth and life support system gauges is to be verified;

- Life support system gauges (which indicate pressure critical to life support functions) are to be examined for functionality.

.3 Temperature and Humidity Control

- Calibration evidence of all available instrumentation is to be examined;

- Functional tests of the following is to be carried out:

  - Heaters in chambers, bells and HES;
  - Cooling systems for divers (if fitted);
  - Environment conditioning units (by temperature monitoring);
  - Standby power supply to the heating/ cooling system to maintain operations for the period of diver recovery (in case of main power failure);

.4 Gas Contamination Analysis

- Verification of calibration of gas analyzers and arrangements for monitoring of Carbon dioxide, Oxygen, temperature, relative humidity in chamber;

- Primary and secondary means of Carbon dioxide scrubbing arrangements are to be examined with special attention to check that the secondary Carbon dioxide scrubbing arrangement provided is independent of any surface power supply and has minimum endurance of 24 [hrs];

.5 Domestic/ Sanitary Systems

- Internal inspection of sewage tanks;

- Functional test of toilet flush (special attention to safe working under pressure) and bilge drains in chambers (special attention to chamber shell under deck plating. Ultrasonic measurements may be carried out at the discretion of the Surveyor).

.6 Auxiliary Services to Life Support Equipment

- Main and emergency power supplies for following are to be examined/ tested;

  - Lighting of chambers and bell;
  - Monitoring devices;
  - Control consoles;
  - Normal and emergency life support systems;
  - Alarm systems including fire loops;
  - DP alarms

- General condition of switchboards, breakers and cables including electrical hygiene, earth leakage detection systems and alarms is to be examined;

- Changeover from main to emergency supplies is to be tested.

18.2.2.3 Communication

.1 The listed alarms and record of their checks as part of their planned maintenance by crew is to be verified.

.2 Functional checks of the following are to be carried out:

- CCTV systems;
- sound powered telephone;
- recording instruments.

.3 Operational checks of primary and secondary means of communication are to be undertaken:

- between bridge and dive control station;
- dive control and
  - bells
  - chambers
  - divers in water
  - diving machinery areas
  - winch/ crane operator

.4 Ultrasound underwater telephones may be checked by simulation or during test dive.

18.2.2.4 Launch and Recovery Systems

.1 General

- Bell lifting arrangements, especially load bearing components are to be carefully examined, with NDE as required;

- Attachments and framework, supporting steelwork are to be examined for signs of corrosion, with NDE as necessary;

- General condition of wire rope and its ends is to be visually inspected. Lubrication records and records of exchange of ends are to be checked;

- Dynamic load test of system is to be carried out on main and emergency power supply. The alarm and safety functions are to be verified;

- Simulated power failure test of launch and recovery system in accordance with laid down procedures for emergency retrieval is to be performed in presence of Surveyor;

- Hydraulic power system during launch and recovery is to be examined for

  - unusually high vibration levels
  - oil leakage
  - pressure peaks and jerking

- Oil hygiene analysis is to be carried out, as necessary;

- Bell emergency release mechanism is to be tested.

.2 Controls

- The main electrical power supplies to the following are to be checked:

  - Monitoring devices
  - Alarm systems
  - Control consoles
  - Switchboards, breakers

- The correct operation of change-over from main to emergency supply is to be verified.

.3 Auxiliary Services to Launch and Recovery Systems

- Close examination of umbilical winch systems, including brake and carry out function tests;

- Examine condition of umbilical and safety provisions to stop umbilicals from jumping out of sheaves;

- Examine breathing apparatus provided for winch operator in case of fire related emergency, requiring bell recovery.

18.2.2.5 Safety Equipment

- The condition of A-60 insulation towards any enclosed spaces from the outer area of the diving system is to be examined;

- The alarms, safety limits and failure conditions of the fixed fire-fighting systems is to be verified;

- The quantity and efficacy of portable fire-extinguishers (as per approved plan), is to be verified.

18.3 Additional requirements for Third Annual Survey

18.3.1 In addition to the annual survey requirements stipulated in 18.2, the requirements indicated in the succeeding paragraphs are to be additionally undertaken at every third annual survey, as applicable:

18.3.1.1 Pressure Equipment

.1 Pressure Vessels for Human Occupancy

- Leak test of bell and chamber to Maximum Allowable Working Pressure (MAWP) with minimum 20% Helium. Leak test of pressure equipment is to be carried out at low and high pressures by increasing the pressure to the working pressure, stepwise. Leak test is to be carried out as per approved procedure, adopting appropriate safety precautions listed in the procedure. The procedure is to include an inspection for leaks at low pressure before increasing to MAWP. The test duration is to be minimum 6 [hrs].

.2 Gas Storage & Pressure Vessels in Supply and Return Lines

- Leak test of gas containers and pressure vessels to minimum 10% Helium. Precautions and test duration to be as per 18.3.1.1.1;

- Function test of valves on permanently installed gas bottles is to be undertaken.

Note: Leak tests are normally to be carried out with a minimum of 10% Helium, if the pressure vessel or piping is designed to hold Heliox mixtures or pure Helium. Due to the inherent fire risk with the use of air at high pressure, it is recommended that leak tests may be carried out incorporating Nitrogen, where applicable.

.3 Pumps and Compressors

- Running condition test of pumps and compressors is to be carried out;

- Safety valves are to be examined/ tested as per manufacturer's instructions.

.4 System components including piping, umbilicals, hoses, valves, filters etc

- Leak test of pipe work to MAWP with minimum 10% Helium;

- Manual/ automatic control valves are to be randomly tested and recorded ;

- Examine and function test the main bell umbilical to MAWP of hoses.

18.3.1.2 Controls

.1 Gas Supply and Distribution

- Life support systems including pipe work and reclaim units are to be examined and tested.

.2 Depth/ Pressure Control

- As per scope of Annual Survey

.3 Temperature and Humidity Control

- As per scope of Annual Survey

.4 Gas Contamination Analysis

- As per scope of Annual Survey

.5 Domestic/ Sanitary Systems

- As per scope of Annual Survey

.6 Auxiliary Services to Life Support Equipment

- As per scope of Annual Survey

18.3.1.3 Communication

- Scope of annual survey is to be applied for primary, secondary and emergency means of communication;

- Listed alarms and record of their checks/ routine tests as part of planned maintenance system by crew are to be verified, as applicable;

- At least the following alarms, if fitted, are to be function tested:

  - High/ low pressure alarm – chamber
  - Temperature alarm – chamber
  - Humidity alarm – chamber
  - Divers hot water temperature alarm
  - Divers hot water pressure alarm
  - High pressure alarm – gas delivery compressor
  - Low pressure alarm – compressor cooling system
  - Low pressure lub oil alarm – compressor
  - High level alarm for gas reclaim bag
  - High/low alarm – Oxygen analyzers
  - Oxygen sensors/ detectors in control stations

18.3.1.4 Launch and Recovery Systems

.1 General

(a) For submergence launch and recovery system:

- The working weight of the bell is to be determined, compared with previous weight and recorded;

- The following alarms for hydraulic systems for bell launch and recovery are to be tested:

  - Low pressure alarm
  - High temperature alarm
  - Low oil level in tank alarm

.2 Controls

- The power failure alarms for controls of launch and recovery systems, including (for hydraulic system) are to be tested:

  - Low pressure alarm
  - High temperature alarm
  - Low oil in tank alarm

- All alarms are to be function tested.

18.3.1.5 Safety Equipment

- The fire detection and alarm system is to be tested;

- One portable extinguisher at random, is to be function tested;

- Blow through with air of water based fixed extinguishing system is to be carried out to clear the lines;

- Records of last inspection of the fixed extinguishing system are to be reviewed by the Surveyor.

18.4 Special Surveys

18.4.1 Scope

18.4.1.1 Special surveys are to be carried out at 5 yearly intervals before the anniversary date. In addition to the requirements of the third annual survey, the scope of special survey is to be as described in 18.4.2 to 18.4.7.

18.4.2 Pressure Tests

.1 Pressure tests are to be carried out in accordance with an approved procedure, based on a recognized national/ international standard for the relevant pressure vessels. Procedures for testing are to be submitted to IRS, well in advance for review.

.2 The pressure test is to be repeated when the modifications to the pressure boundaries have been carried out and the test requirements apply as given for new pressure vessels.

.3 All pressure tests are to be carried out in presence of IRS Surveyor.

.4 A thorough internal and external visual inspection is to be carried out, prior to hydro tests.

.5 If diving bells are used for observation diving, they are to be hydro-tested to the external pressure test pressure, as per the design code.

18.4.3 Pressure Equipment

.1 Pressure Vessels for Human Occupancy

- Bell insulation is to be examined and it is to be determined if affected areas require renewal because of damage/ corrosion. Ultrasonic examination may be carried out, as necessary;

- Areas around windows are to be subject to critical examination;

- Chamber and bell are to be hydro-tested as per the manual and recorded.

.2 Gas Storage & Pressure Vessels in Supply and Return Lines

- Gas storage tubes, air and gas tanks, sewage tanks, hot water tanks are to be hydro tested and recorded.

.3 Pumps and Compressors

- As per scope of third annual survey

.4 System components including piping, umbilicals, hoses, valves, filters etc

- Pressure test of piping systems is to be carried out.

18.4.4 Controls

Survey of the following items is to be carried out with the scope of survey same as that of third annual survey:

.1 Gas Supply and Distribution

.2 Depth/ Pressure Control

.3 Temperature and Humidity Control

.4 Gas Contamination Analysis

.5 Domestic/ Sanitary Systems

.6 Auxiliary Services to Life Support Equipment

18.4.5 Communication

- Primary, secondary and emergency means of communication are to be examined as per scope of third annual survey.

18.4.6 Launch and Recovery Systems

.1 General

(a) For submergence launch and recovery system:

- Bell ballast weight release is to be load tested and NDE to be carried out on load bearing members;
- Emergency retrieval of bell to be tested.

(b) For surface launch and recovery:

- Various systems are to be load tested as per manual and NDE to be carried out on load bearing members;

.2 Controls

- As per scope of third annual survey.

.3 Auxiliary Services to Launch and Recovery Systems

- As per scope of third annual survey.

18.4.7 Safety Equipment

- As per scope of third annual survey.

18.5 Surveys of Hyperbaric Evacuation Systems (HES)

18.5.1 Initial Surveys

.1 The requirements for initial surveys and classification of Hyperbaric Evacuation Systems (HES) are laid down in Pt.5, Ch. 26, Sec. 4.

.2 Statutory requirements of national authorities/ flag administrations are to be taken into account whilst approving and surveying HES.

.3 The interface between the HES and the installed diving system is to be examined carefully so that the HES does not become a hazard to the diving system operations.

.4 HES are connected to the diving system and are to be surveyed in the same manner as the main diving system. Corrosion on the chamber exterior is to be examined carefully due to high humidity levels.

18.5.2 Annual and Special Surveys of HES

18.5.2.1 The initial survey requirements for HES, stipulated in Cl. 4.4.1 of Pt.5, Ch.26, Sec. 4 are to be applied for all annual surveys in addition to the scope laid down below.

18.5.2.2 Annual and Special Survey requirements for components of the HES are indicated in 18.5.2.3 to 18.5.2.7

18.5.2.3 Pressure Equipment

.1 Pressure Vessels for Human Occupancy

- Annual and special survey requirements as applicable to diving systems may be followed.

.2 Gas Storage & Pressure Vessels in Supply and Return Lines

- Examine if gas cylinders exposed to sea water are certified and tested every two years;
- For other components, periodical survey requirements as applicable to diving systems are to be applied.

.3 Pumps and Compressors

- Annual and special survey requirements as applicable to diving systems are to be applied

.4 System components including piping, umbilicals, hoses, valves, filters etc

- Examine, if all valves are firmly secured to prevent any movement due to ship motions in rough weather;
- Examine, if all external valves on the chambers are secured “open” to prevent accidental operation during deployment of HEU.

18.5.2.4 Controls

Annual and special survey requirements are to be as applicable for diving systems, for items .1 to .6, with additional requirements where indicated for each item:

.1 Gas Supply and Distribution

- The following are to be additionally verified at each annual survey:

- Oxygen supply is fitted with a device to ensure Oxygen injection at controlled rate;

- Availability of sufficient Oxygen for metabolic make-up for the maximum complement of divers at a rate of 0.5 [lit/min/diver], for a minimum duration of 24 [hrs];

- There is a minimum amount of Helium/ Oxygen carried, sufficient to compensate for the use of medical locks, as specified by the equipment manufacturer.

.2 Depth/ Pressure Control

.3 Temperature and Humidity Control

- Annual and special survey requirements are to be as applicable to diving systems may be followed. In addition, the following are to be verified at each annual survey:

  - Confirm that there are adequate means of maintaining the diver's thermal balance in the compression chamber to the required level, for a minimum of 24 [hrs];

  - Function test of the external fired diesel heater (if fitted).

.4 Gas Contamination Analysis

.5 Domestic/ Sanitary Systems

.6 Auxiliary Services to Life Support Equipment

- The following are to be additionally verified at each annual survey:

  - The safety provisions applied to reduce potential hazards from battery charging;

  - Ducted hydrogen gas ventilation for safe dumping;

  - Housing of rechargeable batteries in separate well ventilated area, located outside the crew area;

  - Precautions as laid down by the manufacturer being followed for in-situ charging of batteries.

18.5.2.5 Communication

Annual and special survey requirements are to be as applicable to diving systems for items .1 to .4, with additional requirements where indicated for each item:

.1 Primary Means:

- Additionally, the following are to be verified at each annual survey:

  - Examine, if the hard wired communication system linking HES launch control/ HES internal/ saturation life support control is available and effective.

.2 Secondary Means:

.3 Emergency Means:

- Additionally, at each annual survey, examine if the HEU is fitted with relocation devices including:

  - Radar reflector
  - Strobe Light
  - Radio distress beacon

.4 Alarms:

18.5.2.6 Launch and Recovery Systems

.1 General

- Manufacturer's instructions for periodical surveys are to be followed;

- Examine HES release arrangements;

- Launch test the HES with a full load during surveys. In case of a float away chamber, a floatation test is to be carried out with full load;

- Examine if a suitable method of assisting an injured/ unconscious diver in to the chamber is available;

- Examine if, safety locking mechanism is fitted between the saturation diving complex and HES, and the same is effective;

- Examine fall length and confirm that the same allows the HEU to be fully supported in water when the ship/ installation is in the lightest sea-going state. The same is to be determined at the worst angle of list and trim on the side where the HEU is located;

- Examine falls for turning and deterioration. Falls are to be turned end to end at 30 month intervals and renewed when deteriorated, or at intervals not exceeding 5 years;

- Load test of HEU launch system to be carried out, as applicable on annual basis;
- Where secondary means of launch is provided, the launch of the HEU by secondary means is to be tested under same conditions as primary means of launch.

2 Controls

- Annual and special survey requirements as applicable to diving systems may be followed.

.3 Auxiliary Services to Launch and Recovery Systems

- Annual and special survey requirements as applicable to diving systems may be followed.

18.5.2.7 Safety Equipment

- As per the relevant Statutory requirements.

18.6 Surveys for Transit Damage

18.6.1 During transportation of the diving system or hyperbaric facility, precautions are to be taken to protect the pressure hull, external structures, acrylic windows, batteries, etc. from undue deterioration or damage.

18.6.2 A survey for transit damage is to be conducted after the transportation of diving system or hyperbaric facility from the manufacturer's or the assembler's plant to the operational location or from one location of operations to another.

18.6.3 This survey is to include but may not be limited to the following:

- Pressure boundary and its components are to be visually checked for damage.
- Systems and components are to be inspected, and recalibration of instruments may be required if deemed necessary by the Surveyor.
- External structures, fairings and skins are to be checked for damage.
- Further in-depth examination may be required by and at the discretion of the Surveyor.

18.6.4 If the survey is carried out by the Owner and damage is found which affects or may affect classification, IRS is to be advised of the details and provisions are to be made for examination by the Surveyor at first available opportunity.

End of Chapter

Rules and Regulations for the Construction and Classification of Steel Ships

Part 2

Inspection and Testing of Materials

July 2016

IRCLASS
Indian Register of Shipping

Indian Register of Shipping

Part 2

Inspection and Testing of Materials

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Chapter 1

General Requirements

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Section 1

Conditions for Manufacture, Survey and Certification

1.1 Scope

1.1.1 Materials, used for the construction or repair of the hull and machinery of ships which are classed or intended to be classed with IRS, are to be manufactured, tested and inspected in accordance with the requirements of this Part.

1.1.2 Materials complying with recognized national or international standards with specifications equivalent to the requirements of this Part may be accepted.

1.2 Information to be supplied to the manufacturer

1.2.1 The ship or machinery builder is to provide the manufacturer with such information as is necessary to ensure that inspection and testing can be carried out in accordance with these Rules.

1.3 Manufacture

1.3.1 Materials used for the construction or repair of the hull and machinery of ships which are classed or intended to be classed with IRS are to be made at works which have been approved by IRS for the type of the product being supplied.

1.3.2 The manufacturer should demonstrate to the satisfaction of IRS that necessary manufacturing and testing facilities are available and are supervised by qualified personnel.

1.3.3 Approval of manufacturers with respect to the materials and grades covered by this Part will be considered by IRS on the basis of a detailed description of the manufacturing process and inspection routines, results from testing of materials and a report made by IRS Surveyors confirming the information given by the works and results.

1.3.4 Where the manufacturer has more than one works, approval for individual works would be required.

1.4 Survey procedure

1.4.1 The Surveyors are to be allowed access to all the relevant parts of the works and are to be provided with necessary facilities and information to enable them to verify that manufacture is being carried out in accordance with the approved procedure. Adequate facilities are also to be provided for the selection of test materials, the witnessing of mechanical tests and the examination of materials, as required by these Rules.

1.4.2 Prior to the submission of material for acceptance, manufacturers are to provide the Surveyors with details of the order specification and any special conditions additional to the Rule requirements.

1.4.3 Before final acceptance, all materials are to be submitted to specified tests and examinations under conditions acceptable to the Surveyors. The results are to comply with Rules and all materials are to be to the satisfaction of the Surveyors.

1.4.4 The specified tests and examinations are to be carried out prior to the dispatch of all finished materials from the manufacturer's works. Where materials are supplied in the rough or unfinished condition, as many as possible of the specified tests are to be carried out by the manufacturer and any tests or examinations not completed are to be carried out in consultation with the Surveyors, at a subsequent stage of manufacture.

1.4.5 In the event of any material proving unsatisfactory, during subsequent working, machining or fabrication, it is to be rejected, not withstanding any previous certification.

1.5 Chemical composition

1.5.1 The chemical composition of the ladle samples is to be determined by the manufacturer in an adequately equipped and competently staffed laboratory. The manufacturer's analysis will be accepted, but may be subject to occasional independent checks if required by the Surveyors.

1.5.2 At the discretion of the Surveyors, a check chemical analysis of suitable samples from products may also be required. These samples are to be taken from the material used for mechanical tests, but where this is not practicable an alternative procedure for obtaining a representative sample is to be agreed with the manufacturer.

1.6 Heat treatment

1.6.1 Materials are to be supplied in the condition specified in, or permitted by the Rules. Heat treatment is to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means for control and recording of temperature. The furnace dimensions are to be such as to allow the whole item to be uniformly heated to the necessary temperature. In the case of very large components which require heat treatment, alternative methods will be specially considered.

1.7 Test material

1.7.1 Sufficient test material is to be provided for the preparation of the tests detailed in the specific requirements. It is, however, in the interests of manufacturers to provide additional material for any retests which may be necessary, as insufficient or unacceptable test material may be a cause for rejection.

1.7.2 The test material is to be representative of the item or batch and is not to be separated until all the specified heat treatment has been completed, except where provision for an alternative procedure is made in the subsequent chapters of this Part.

In case of castings where separately cast test samples are accepted, the test samples are to be cooled down under the same conditions as the castings.

1.7.3 All test material is to be selected by the surveyor and identified by suitable markings which are to be maintained during the preparation of the test specimen.

1.8 Mechanical tests

1.8.1 The number and direction of test specimens and their dimensions are to be in accordance with the requirements of subsequent chapters of this Part and the specific requirements for the product.

1.8.2 Where Charpy impact tests are required, a set of three test specimens are to be prepared and the average energy value is to comply with the requirements of subsequent Chapters of this part. One individual value may be less than the required average value provided that it is not less than 70 per cent of that value.

1.8.3 Where metric or imperial units are to be used for acceptance testing, the specified values are to be converted in accordance with the appropriate conversions given in Table 1.8.1.

Table 1.8.1 : **Conversion of SI units to metric and imperial units**

1 N/mm^2 or Mpa	= 0.102 kgf/mm^2
1 N/mm^2 or Mpa	= 0.0647 $tonf/in^2$
1 N/mm^2 or Mpa	= 0.145 x 10^3 lbf/in^2
1 J	= 0.102 Kgf m
1 J	= 0.738 ft Ibs
1 Kgf/mm^2	= 9.81 N/mm^2 or MPa
1 $tonf/in^2$	= 15.45 N/mm^2 or MPa
1 Ibf/in^2	= 6.89 x 10^{-3} MPa
1 kgf m	= 9.81 J
1 ft lbf	= 1.36 J

Notes :

The conversions may be rounded to the nearest multiples as follows :

1	For tensile strength values at ambient temperature	1 Kgf/mm^2 0.5 $tonf/in^2$ 1 x 10^3 $lbf.in^2$ 10N/mm^2
2	For yield and proof stress values at ambient temperature	0.5 kgf/mm^2 0.2 $tonf/in^2$ 0.5 x 10^3 lbf/in^2 5 N/mm^2
3	For lower yield or proof stress values at elevated temperatures and stress to rupture.	0.1 kgf/mm^2 0.05 $tonf/in^2$ 0.1 x 10^3 lbf/in^2 1 N/mm^2
4	For impact energy values	0.1 kgf m 1 ft lbf 1 J

1.9 Definitions

1.9.1 The following definitions are applicable to this Part:

Item A single forging, casting, plate, tube or other rolled product as delivered.

Piece The rolled product from a single slab or billet or from a single ingot if this is rolled directly into plates, strips, sections or bars.

Batch A number of similar items or pieces presented as a group for acceptance testing.

1.10 Retest procedures

1.10.1 Where the result of any test, other than an impact test, does not comply with the requirements, two additional tests of the same type may be taken. For acceptance of the material satisfactory results are to be obtained from both of these tests.

1.10.2 Where the results from a set of three impact test specimens do not comply with the requirements, an additional set of three impact test specimens may be tested provided that not more than two individual values are less than the required average value and, of these, not more than one is less than 70 per cent of this average value. The results obtained are to be combined with the original results to form a new average which, for acceptance, is not to be less than the required average value. Additionally, for these combined results, not more than two individual values are to be less than the required average value and, of these, not more than one is to be less than 70 per cent of this average value.

1.10.3 The additional tests detailed in 1.10.1 and 1.10.2 are, where possible, to be taken from material adjacent to the original tests. For castings, however, where insufficient material remains in the original test samples, the additional tests may be prepared from other test samples representative of the castings.

1.10.4 When unsatisfactory results are obtained from tests representative of a batch of material, the item or piece from which the tests were taken is to be rejected. The remainder of the batch may be accepted provided that two further items or pieces are selected and tested with satisfactory results. If the tests from one or both of these additional items or pieces give unsatisfactory results, the batch is to be rejected.

1.10.5 When a batch is rejected, the remaining items or pieces in the batch may be re-submitted individually for test, and those which give satisfactory results may be considered for acceptance by the Surveyors.

1.10.6 At the option of the manufacturer, rejected material may be re-submitted as another grade and may then be considered for acceptance by the Surveyors, provided that the test results comply with the appropriate requirements.

1.10.7 When material which is intended to be supplied in the "as rolled" or "hot finished" condition fails test, it may be suitably heat treated and re-submitted for test, with the prior concurrence of the ship or machinery builder. Similarly materials supplied in the heat-treated condition may be re-heat treated and re-submitted for test.

1.11 Visual and non-destructive examination

1.11.1 Prior to the final acceptance of materials, surface inspection, verification of dimensions and non-destructive examination are to be carried out in accordance with the requirements detailed in subsequent chapters of this Part.

1.11.2 When there is visible evidence to doubt the soundness of any material or component, such as flaws in test specimens or suspicious surface marks, the manufacturer is expected to prove the quality of the material by any acceptable method.

1.12 Rectification of defective material

1.12.1 Small surface imperfections may be removed by mechanical means provided that, after such treatment, the dimensions are acceptable, the area is proved free from defects and the rectification has been completed in accordance with applicable requirements of subsequent chapters of this Part and to the satisfaction of Surveyors.

1.12.2 The repair of defects by welding can be accepted only when permitted by the appropriate specific requirements and provided that the agreement of the Surveyor is obtained before the work is commenced. When a repair has been agreed, it is necessary in all cases to prove by suitable methods of non-destructive examination that the defects have been completely removed before welding is commenced. Welding procedures and inspection on completion of the repair are to be in accordance with the appropriate specific requirement and are to be to the satisfaction of the Surveyor.

1.13 Identification of materials

1.13.1 The manufacturer is to adopt a system of identification which will enable all finished material to be traced to the original cast, and the Surveyors are to be given all facilities for so tracing the material when required. When any item has been identified by the personal mark of a Surveyor, or his deputy, this is not to be removed until an acceptable new identification mark has been made. Failure to comply with this condition will render the item liable to rejection.

1.13.2 Before any item is finally accepted it is to be clearly marked by the manufacturer in at least one place with the particulars detailed in the appropriate specific requirements.

1.13.3 Hard stamping is to be used except where this may be detrimental to the material, in which case stenciling, painting or electric etching is to be used. Paints used to identify alloy steels are to be free from lead, copper, zinc or tin, i.e., the dried film is not to contain any of these elements in quantities more than 250 ppm.

1.13.4 Where a number of identical items are securely fastened together in bundles, the manufacturer need only brand the top of each bundle. Alternatively a durable label giving the required particulars may be attached to each bundle.

Section 2

Certification of Materials Based on Alternative Certification Scheme

2.1 General

2.1.1 Alternative procedures for survey and testing may be accepted by IRS at works where materials are manufactured under closely control rolled conditions by semi-continuous or continuous processes under the Alternative Certification Scheme (ACS), as detailed in Part1, Chapter 1, Section 4 of the Rules.

2.1.2 Where it is considered that compliance with Rule requirements can be satisfactorily achieved, IRS will issue a Quality Assurance Approval Certificate, based on the ACS to the manufacturer.

2.1.3 The quality system procedures and practices of a manufacturer who has been granted approval will be kept under continuous review and audited as per the ACS.

2.2 Requirements for approval

2.2.1 The conditions for approval are broadly outlined in Pt.1, Ch.1, Sec. 4, Cl. 4.3 of the Rules.

2.3 Information required for approval

2.3.1 Manufacturers applying for approval under this scheme are to submit the information required by 2.3.2 to 2.3.6, in addition to the requirements of the ACS (Pt.1, Ch.1, Sec. 4, Cl. 4.4).

2.3.2 A detailed specification for each product.

2.3.3 An outline description of all important manufacturing plant and equipments. This is to include a production flow chart indicating all stages where testing and inspection are carried out along with details of equipments used for measuring and testing.

2.3.4 The system used for the identification and traceability of raw materials, semi-finished and finished Products.

2.3.5 Information on the system of procurement and acceptance of materials e.g. ingots, billets or blooms for further processing where the manufacturer does not produce such raw materials.

2.3.6 Consolidated test results, physical, chemical, non-destructive tests etc. for a period of preceding three months of products, if possible, covering the full range of thickness, weight range and grades for which approval is sought. The data is to include the number of samples, minimum, maximum, average value and standard deviation. For high strength ship steels, the carbon equivalent values are also required. The data is to also include numbers of rejections during manufacture as well as after delivery and reasons thereof.

2.4 Assessment and approval, maintenance of approval and certification of products would be generally based on the ACS detailed in Pt.1, Ch.1, Sec.4 of the Rules.

End of Chapter

Chapter 2

Mechanical Testing Procedures

Contents

Section 1

General Requirements

1.1 General

1.1.1 All tests are to be carried out by competent personnel. The machines are to be maintained in satisfactory and accurate condition and are to be recalibrated at approximately annual intervals. This calibration is to be carried out by a nationally recognized Authority or other organization of standing and is to be carried out to the satisfaction of Surveyors. The accuracy of test machines is to be within ± one per cent. A record of all calibrations is to be kept available in the test house.

Testing machines are to be calibrated in accordance with the following or other equivalent recognized standards:

a) Tensile / compression testing : ISO 7500-1
b) Impact testing : ISO 148-2

1.2 Selection of test samples

1.2.1 Test samples are to be selected by the Surveyor unless otherwise agreed.

1.2.2 All materials in a batch presented for testing are to be of the same product form (e.g. plates, sections, bars). Normally, the materials are to be from the same cast and in the same condition of heat treatment.

1.3 Preparation of test specimens

1.3.1 If test samples are cut from material by flame cutting or shearing, a reasonable margin is required to enable sufficient material to be removed from the cut edges during final machining.

1.3.2 Test specimens are to be cut and prepared in a manner which does not affect their properties, i.e. not subjected to any significant cold straining or heating.

1.3.3 Where possible, test specimens from rolled materials are to retain their rolled surface on both sides.

1.4 Discarding of test specimens

1.4.1 If a test specimen fails because of faulty manufacture, visible defects, or incorrect operation of the testing machine, it may be discarded at the Surveyor's discretion and replaced by a new test specimen prepared from material adjacent to the original test.

Section 2

Tensile Testing

2.1 Dimensions of tensile test specimens

2.1.1 Generally, proportional test specimens with a gauge length of $5.65\sqrt{S_o}$ (where S_o is the cross-sectional area of the test length) are to be used. Where it is not possible to use such specimens, non-proportional specimens may be considered.

2.1.2 For the purpose of determining the different parameters related to tensile testing, three different types of test specimens may be used :

- Round test specimens;
- Flat test specimens; and
- Full cross-section test specimens.

See also Fig.2.1.1.

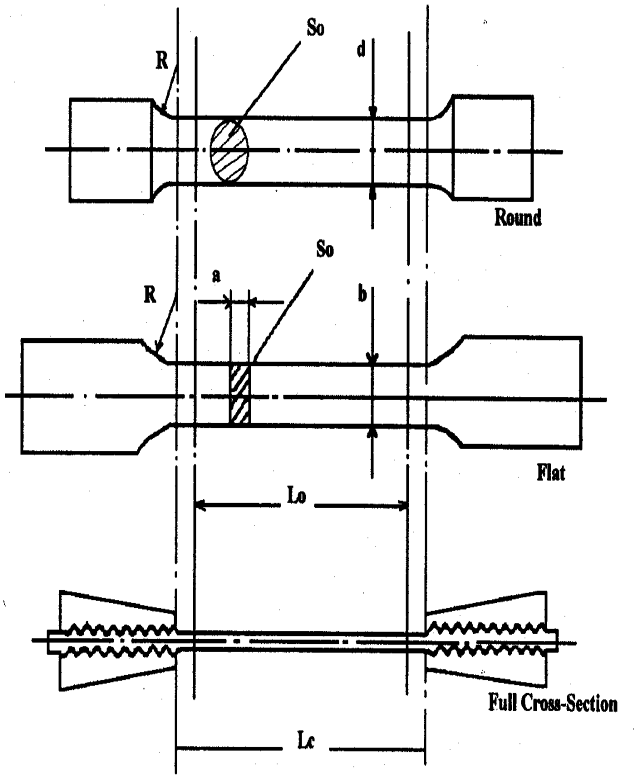


Fig. 2.1.1 : Tensile test specimens

2.1.2.1 The following symbols have been used in the figure and in subsequent paragraphs:-

d =diameter
a =thickness of specimen
b =width
Lo = Original gauge length
Lc = Parallel length
So = Original cross-sectional area
R = Transition radius
D =External tube diameter
t = plate thickness

2.1.2.2 The gauge length may be rounded off to the nearest 5 [mm] provided that the difference between this length and Lo is less than 10% of Lo.

2.1.2.3 For plates with thickness equal to and greater than 3 [mm], test specimen according to alternatives A or B given below are to be used. Where the capacity of the available testing machine is insufficient to allow the use of a test specimen of full thickness, this may be reduced by machining one of the rolled surfaces.

Alternatively for materials over 40 [mm] thick, proportional round test specimens with dimensions as specified in C below may be used.

Alternative A, Non-proportional flat test specimen

a = t
b =25 [mm]
Lo =200 [mm]
Lc $\geq$ 212.5 [mm]
R =25 [mm]

Alternative B, Proportional flat test specimen

a = t

b =25 [mm]

Lo = 5.65 $\sqrt{S_o}$

Lc $\approx$Lo + 2 $\sqrt{S_o}$

R =25 [mm]

Alternative C, round test specimen

d =14 [mm] in general, but in no case less than 10 mm nor more than 20 [mm].

Lo = 5d [mm

Lc $\geq$ Lo + d/2 [mm]

R =10 [mm], in general
$\geq$ 1.5 d [mm], for nodular cast iron and materials with a specified elongation of less than 10%.

2.1.2.4 The round test specimen is to be located with its center t/4 from the plate surface or as close to this position as possible.

2.1.2.5 For sheets and strips with thickness less than 3 [mm]

a = t
b =12.5 [mm]
Lo =50 [mm]
Lc $\approx$75 [mm]
R =25 [mm]

2.1.2.6 Wires: Full cross sectional test specimen with the following dimensions is to be used:

Lo =200 [mm]

Lc =Lo + 50 [mm].

2.1.2.7 For forgings, castings (excluding grey cast iron) and bars round test specimens with dimensions as specified in alternative C of 2.1.2.3 are usually to be used.

2.1.2.8 If for special reasons, other dimensions are to be used, they will have to conform with the following geometric relationship:

Lo =5d;

Lc =Lo + d:

R=10 [mm], except for materials with a specified minimum elongation A $\leq$ 10 per cent, where R is to be 1.5 x d.

2.1.2.9 For tubes, test specimen according to alternative A or B below are to be used:

Alternative A :- Full cross-section test specimens with plugged ends -

Lo = 5.65 $\sqrt{S_o}$

Lc $\approx$ Lo + D/2

Lc is the distance between the grips or the plugs, whichever is smaller.

Alternative B :- Strip
a =wall thickness of tube
b $\geq$ 12 [mm]
Lo = 5.65 $\sqrt{S_o}$
Lc = Lo + 2b

The parallel test length is not to be flattened. but the enlarged ends may be flattened for gripping in the testing machine.

Round test specimens may also be used provided that the wall thickness is sufficient to allow the machining of such specimens to the dimensions in alternative C in 2.1.2.3 above with their axes located at the midwall thickness.

2.1.2.10 The above is subject to any specific dimensions or minimum cross-sectional area requirements, with respect to test specimens, given in any subsequent Chapters of this Part.

2.1.2.11 Tensile test specimens for grey cast iron are to be machined to the dimensions shown in Fig.2.1.2. Usually test specimens are machined from separately cast standard test coupons with 30 [mm] diameter.

2.1.2.12 The tolerances on specimen dimensions are to be in accordance with ISO

6892-98 or other recognised standards as appropriate.

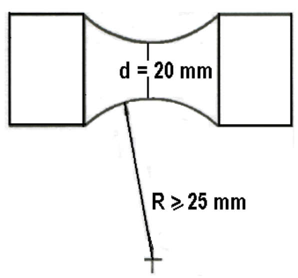


Fig : 2.1.2 : Tensile test specimen for grey cast iron

2.2 Fracture elongation

2.2.1 Unless otherwise specified, the elongation values in this part correspond to those required for proportional test specimens over a gauge length 5.65 $\sqrt{S_o}$.

If any part of the fracture takes place outside of the middle one-third of the original gauge length, the elongation value obtained may not be representative of the material. In such cases if the elongation measured is less than the minimum requirements, the test result may be discarded and a retest carried out.

2.2.2 If the material is ferritic steel of low or medium strength and not cold worked the elongation may also be measured on a non-proportional gauge length after agreement with IRS.

In that case the elongation required is to be calculated from the following formula:

$$A_o = 2 \times A_s \left[\frac{\sqrt{S_o}}{L_o} \right]^{0.4}$$

where,

A_o = Required elongation for the non-proportional test specimen

A_s = Specified elongation on a gauge length of 5.65$\sqrt{S_o}$

S_o = Cross-sectional area of test specimen

L_o = Gauge length of test specimen.

2.3 Definition of yield stress

2.3.1 The yield phenomenon is not exhibited by all the steels detailed in this Part but, for simplification the term "Yield Stress" is used throughout when requirements are specified for acceptance testing at ambient temperature.

2.3.2 Where reference is made to "Yield Stress" in the requirements for carbon, carbon-manganese and alloy steel products and in the requirements for the approval of welding consumables, either the upper yield stress or the 0.2 per cent proof stress under load is to be determined.

2.3.3 For austenitic and duplex stainless steel products and welding consumables, both the 0.2 per cent and 1.0 per cent proof stresses are to be determined.

2.4 Procedure for tensile testing at ambient temperature

2.4.1 Unless otherwise specified, the test is to be carried out at ambient temperature between 10^0C and 35^0C.

2.4.2 Yield stress (Yield point) is to be taken as the value of stress measured at the commencement of plastic deformation at yield or the value of the stress measured at the first peak obtained during yielding even when the peak is equal to or less than any subsequent peaks observed during plastic deformation at yield. The tensile test is to be carried out with an elastic stress rate within the limits indicated in Table 2.4.2.

Table 2.4.2

Modulus of elasticity of the material (E) [N/mm^2]	Rate of stressing [N/mm^2] per second	
	Min.	Max.
< 150 000	2	20
≥ 150 000	6	60

2.4.3 After reaching the yield or proof load, the straining rate may be increased to a maximum of 0.008 per second for the determination of tensile strength.

2.4.4 For steel, the upper yield stress is to be calculated from :

a) the load immediately prior to a distinct drop in the testing machine lever; or

b) the load immediately prior to a fall back in the movement of the pointer or the load at a marked hesitation of this pointer; or

c) a load/extension diagram using the value of load measured either at the commencement of plastic deformation or yield or at the first peak obtained during yielding even when that peak is equal to or less than any subsequent peaks observed.

2.4.5 The 0.2 or 1.0 per cent proof stress (non-proportional elongation) is to be determined from an accurate load/extension diagram by drawing a line parallel to the straight elastic portion and distant from it by an amount representing 0.2 or 1.0 per cent of extensometer gauge length. The point of intersection of this line with the plastic portion of the diagram represents the proof load, from which 0.2 or 1.0 per cent proof stress can be calculated.

2.5 Procedure for tensile testing at elevated temperatures

2.5.1 The test specimens used for the determination of lower yield or 0.2 per cent proof stress at elevated temperatures are to have an extensometer gauge length of not less than 50 [mm] and a cross sectional area of not less than 65 [mm^2]. Where, however, this is precluded by the dimensions of the product or by the test equipment available, the test specimen is to be of the largest practical dimensions.

2.5.2 The heating apparatus is to be such that the temperature of the specimen during testing does not deviate from that specified by more than ± 5°C.

2.5.3 The straining rate when approaching the lower yield or proof load is to be controlled within the range 0.1 to 0.3 per cent of the extensometer gauge length per minute.

2.5.4 The time intervals used for estimation of strain rate from measurements of strain are not to exceed 6 seconds.

Section 3

Impact Tests

3.1 Dimensions of test pieces

3.1.1 Impact tests are to be of either the charpy V-notch or the charpy U-notch type as required by the subsequent Chapters. The test specimens are to be machined to the dimensions and tolerances given in Table 3.1.1 and Table 3.1.2 and are to be carefully checked for dimensional accuracy.

3.1.2 For material under 10 [mm] in thickness the largest possible size of standard subsidiary charpy V-notch is to be prepared with the notch cut in the narrow face. Generally impact tests are not required when the thickness of material is less than 5 [mm] (less than 6 [mm] for pipes and tubes).

Table 3.1.1 : Dimensions and tolerances for charpy V-notch impact test specimens

Dimensions	Nominal	Tolerance
Length [mm]	55	± 0.60
Width [mm]		
- standard specimen	10	± 0.11
- subsize specimen	7.5	± 0.11
- subsize specimen	5	± 0.06
Thickness [mm]	10	± 0.06
Angle of notch	45°	± 2°
Depth below notch [mm]	8	± 0.06
Root radius [mm]	0.25	± 0.025
Distance of notch from end of specimen [mm]	27.5	± 0.42
Angle between plane of symmetry of notch and longitudinal axis of test specimen	90°	± 2°
Ref. Fig.3.1.1		

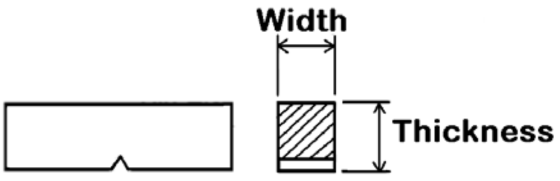


Fig.3.1.1

Table 3.1.2: Dimensions and tolerances for charpy U-notch impact test specimens		
Dimensions	**Nominal**	**Tolerance**
Length [mm]	55	± 0.60
Width [mm]	10	± 0.11
Thickness [mm]	10	± 0.11
Depth of notch [mm]	5	± 0.09
Root radius [mm]	1	± 0.07
Distance of notch from end of test specimen [mm]	27.5	± 0.42
Angle between plane of symmetry of notch and longitudinal axis of test specimen	90°	± 2°
Ref. Fig.3.1.1		

3.2 Testing procedure

3.2.1 All impact tests are to be carried out on Charpy machines having a striking energy of not less than 150J and complying with following requirements:-

a) Distance between supports 40 + 5 [mm] - 0

b) Radius of curvature of supports 1 -1.5 [mm]

c) Taper of supports 1 in 5

d) Angle at tip of hammer 30 ± 1°

e) Radius of curvature of hammer 1.0 -2.5 [mm]

f) Speed of hammer at the instant of striking 4.5 - 7 [m/sec].

3.2.2 Charpy U-notch impact tests are generally to be carried out at ambient temperature. Charpy V- notch impact tests may be carried out at ambient or lower temperatures in accordance with specific requirements given in subsequent Chapters. Where the test temperature is other than ambient, the temperature of the test specimen is to be controlled to within ± 2°C for sufficient time to ensure uniformity throughout the cross section of the test specimen, and suitable precautions are to be taken to prevent any significant change in temperature during the actual test. In cases of dispute, ambient temperature is to be considered as 18°C -27°C.

3.2.3 When reporting results, the units used for expressing the energy absorbed and the testing temperature are to be clearly stated. It is preferred that energy values for both charpy V-notch and charpy U-notch impact tests be expressed in Joules and not [J/cm^2].

3.2.4 The minimum average values for specimens are as given in Table 3.2.4.

Table 3.2.4	
Charpy V-notch specimen size	**Minimum energy, average of 3-specimens**
10 mm x 10 mm	E
10 mm x 7.5 mm	5E/6
10 mm x 5.0 mm	2E/3
Notes: E = the values of energy specified for full thickness 10 mm x 10 mm specimens All other dimensions and tolerances are to be as specified in Table 3.1.1. Only one individual value may be below the specified average value provided it is not less than 70% of that value. In all cases, the largest size Charpy specimens possible for the material thickness shall be machined	

Section 4

Ductility Testing of Pipes and Tubes

4.1 Bend tests

4.1.1 The test specimens are to be cut as circum- ferential strips of full wall thickness and with a width of not less than 40 [mm]. For thick walled pipes, the thickness of the test specimens may be reduced to 20 [mm] by machining. The edges of specimen may be rounded to a radius of 1.6 [mm].

4.1.2 Testing is to be carried out at ambient temperature, and the specimens are to be doubled over, in the direction of the original curvature, around a former. The diameter of the former is to be in accordance with the specific requirements for the material. The test is to be considered satisfactory if, after bending, the specimens are free from cracks and laminations. Small cracks at the edges of the test specimen are to be disregarded.

4.2 Flattening tests

4.2.1 The test specimens are to be cut with the ends perpendicular to the axis of the pipe or tube. The length of the specimen is to be not less than 10 [mm] or greater than 100 [mm].

4.2.2 Testing is to be carried out at ambient temperature and is to consist of flattening the specimens in a direction perpendicular to the longitudinal axis of the pipe. (Reference is made to ISO 8492). Flattening is to be carried out between two plain parallel and rigid platens which extend over both the full length and width after flattening of the test specimen. Flattening is to be continued until the distance between the platens, measured under load, is not greater than the value given by the formula:-

$$H = \frac{t\,(1 + C)}{C + \frac{t}{D}}$$

where,

H = distance between platens [mm];

t = specified thickness of the pipe [mm];

D = Specified outside diameter [mm];

C = a constant dependent on the steel type and detailed in the specific requirements.

After flattening, the specimens are to be free from cracks or other flaws. Small cracks at the ends of the test specimens may be disregarded.

4.2.3 For welded pipes or tubes, the weld is to be placed at an angle of 90° to the direction of the pressure.

4.3 Drift expanding test

4.3.1 The test specimens are to be cut with the ends perpendicular to the axis of the tube. The edges of the end to be tested may be rounded by filing.

Metallic tubes: The length 'L' equal to twice the external diameter 'D' of the tube if the angle of the drift is 30° and L equal to 1.5D if the angle of the drift is 45° or 60°. (Reference ISO 8493). The test piece may be shorter if after testing the remaining cylindrical portion is not less than 0.5D.

The rate of penetration of the mandrel is not to exceed 50 [mm]/minute.

4.3.2 Testing is to be carried out at ambient temperature and is to consist of expanding the end of the tube symmetrically by means of a hardened conical steel mandrel having a total included angle of 45° or 60°. The mandrel is to be forced into the test specimen until the percentage increase in the outside diameter of the end of the test specimen is not less than the value given in the specific requirements for boiler and superheater tubes. The mandrel is to be lubricated, but there is to be no rotation of the tube or mandrel during the test. The expanded portion of the tube is to be free from cracks or other flaws.

4.4 Flanging tests

4.4.1 The test specimens are to be cut with the ends perpendicular to the axis of the tube. The length of the specimens is to be approximately 1.5D. The length may be shorter provided that after testing the remaining cylindrical portion is not less than O.5D (Reference ISO 8494). The edges of the end to be tested may be rounded by filing. The rate of penetration shall not exceed 50 [mm]/minute.

4.4.2 Testing is to be carried out at ambient temperature and is to consist of flanging the end of the tube symmetrically by means of hardened conical steel mandrels.

4.4.3 The first stage of flanging is to be carried out with a conical angled mandrel having an included angle of approximately 90° (See Fig.4.4.3(a)) The completion of the test is achieved with a second forming tool as shown in Fig.4.4.3(b). The mandrels are to be lubricated and there is to be no rotation of the tube or mandrels during the test. The test is to continue until the drifted portion has formed a flange perpendicular to the axis of the test specimens. The percentage increase in the external diameter of the end of specimens is not to be less than the value given in the specific requirements for boiler and superheater tubes. The cylindrical and flanged portion of the tube is to be free from cracks or other flaws.

4.5 Ring expanding test

4.5.1 The test piece consists of a ring having a length of between 10 to 16 [mm]. (Reference ISO 8495). The rate of penetration of the mandrel is not to exceed 30 [mm]/second.

4.6 Ring tensile test

4.6.1 The ring is to have a length of about 15 [mm] with plain and smoothed ends cut perpendicular to the tube axis. The ring is to be drawn to fracture by means of two mandrels placed inside the ring and pulled in tensile testing machine. The rate shall not exceed 5 [mm]/second. (Reference ISO 8496).

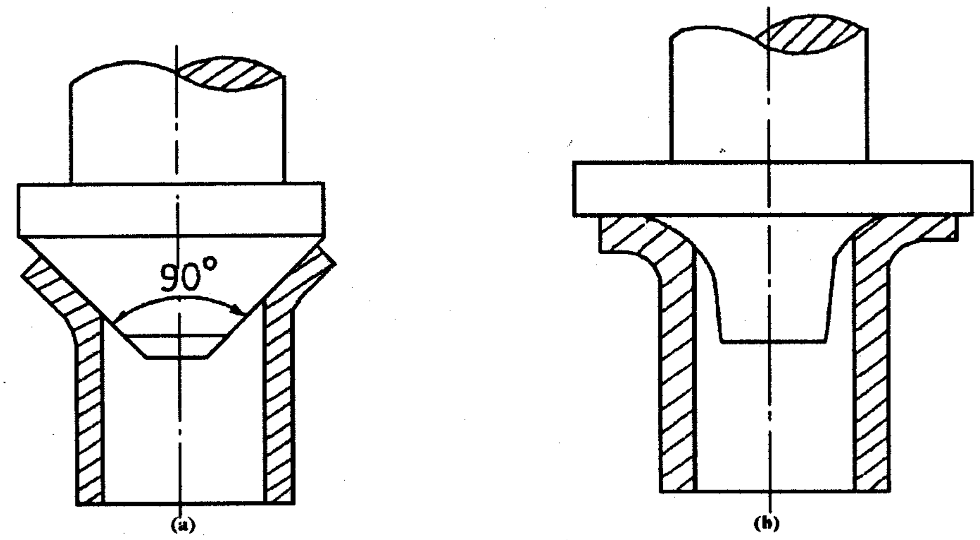


Fig.4.4.3 : Flanging test

Section 5

The Brittle Crack Arrest Toughness Test

5.1 Scope

The standard ESSO test method described in this section is used to estimate the brittle crack arrest toughness value K_{ca} of rolled steel plates for hull of thickness not greater than100 [mm].

5.2 Symbols

Table 5.2 : Symbols used and their meanings

Symbol	Unit	Meaning
t_S	mm	Thickness of test specimen
W_S	mm	Width of test specimen
L_S	mm	Length of test specimen
t_r	mm	Thickness of tab plate
W_r	mm	Width of tab plate
L_r	mm	Length of tab plate
L_P	mm	Distance between pins
a	mm	Length of crack projected on surface normal to the line of load
a_a	mm	Maximum crack length at brittle crack arrest position
T	^oC	Temperature of test specimen
dT/da	$^oC/mm$	Temperature gradient of test specimen
σ	N/mm^2	Gross stress in tested part (load / $W_S.t_S$)
K_{ca}	$N/mm^{3/2}$	Brittle crack arrest toughness value

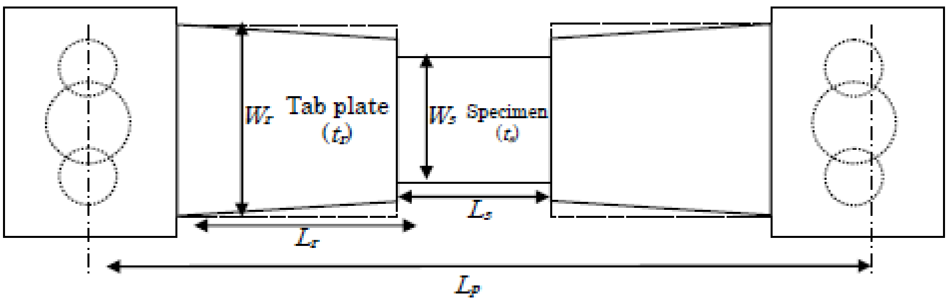


Fig.5.2 : Conceptual view of test specimen, tab and load jig

5.3 Purpose

The purpose of this test is to assess brittle crack arrest toughness with temperature gradient and to obtain the corresponding brittle crack arrest toughness value K_{ca}.

5.4 Standard test specimen

5.4.1 Fig.5.4.1 shows the shape and size of the standard test specimen.

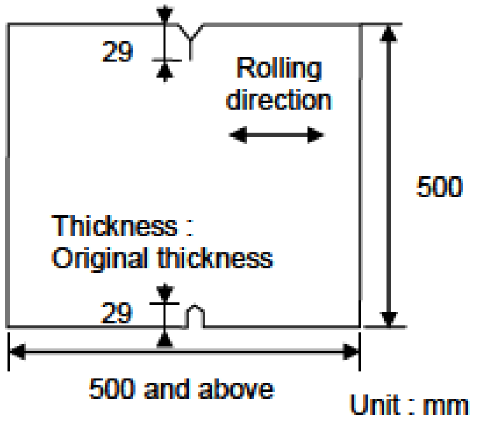


Fig 5.4.1 Shape and size of specimen

5.4.2 The thickness and width of the test specimen is to be in accordance with Table 5.4.2.

Table 5.4.2 : Thickness and width of test specimen	
Thickness, t_s	100[mm] and below
Width of the test specimen W_s	500 [mm]

Note: If the width of the test specimen cannot be made at 500 [mm], it may be taken as 600 [mm].

5.4.3 The test specimens are to be taken from the same steel plate.

5.4.4 Test specimens are to be taken in such a way that the axial direction of the load is parallel to the rolling direction of the steel plate.

5.4.5 The thickness of the test specimen is to be the same as the thickness of the steel plate to be used in the vessel structure.

5 5 Test equipment

5.5.1 The test equipment to be used is to consist of pin load type hydraulic test equipment capable of tensile tests.

5.5.2 The distance between the pins is to be not less than 2,000 [mm]. The distance between pins refers to the distance between the centers of the pin diameters.

5.5.3 Drop weight type or air gun type impact equipment may be used for the impact energy required for generating brittle cracks.

5.5.4 The wedge is to have an angle greater than the upper notch of the test specimen, and an opening force is to be applied on the notch.

5.6 Test preparations

5.6.1 The test piece is to be fixed directly to the pin load jig or by means of weld joint through the tab plate. The overall length of the test specimen and tab plate is to be not less than 3Ws.

The thickness and width of the tab plate are to be in accordance with Table 5.6.1.

Table 5.6.1 : Allowable dimensions of tab plate

Thickness: t_r	Width: W_r
$0.8t_s \le t_r \le 1.5t_s$ (See Notes 1 and 2)	$W_s \le W_r \le 2W_s$

Note 1: t_s : Thickness of test specimen

Note 2: If the tab plate has a thickness smaller than the test specimen, the reflection of stress wave will be on the safer side for the assessment; therefore, considering the actual circumstances for conducting the test, the lower limit of thickness is taken as $0.8t_s$.

5.6.2 Thermocouples are to be fitted at 50 mm pitch on the notch extension line of the test specimen.

5.6.3 If the brittle crack is estimated to deviate from its presumed course, thermocouples are to be fitted at two points separated by 100 mm on the line of load from the notch extension line at the centre of width of the test specimen.

5.6.4 If dynamic measurements are necessary, strain gauges and crack gauges are to be fitted at specific locations.

5.6.5 The test specimen is to be fixed to the testing machine together with the tab plate after welding and the pin load jig.

5.6.6 The impact equipment is to be mounted. The construction of the impact equipment is to be such that the impact energy is correctly transmitted. An appropriate jig is to be arranged to minimize the effect of bending load due to the impact equipment.

5.7 Test method

5.7.1 To eliminate the effect of residual stress or correct the angular deformation of tab welding, a preload less than the test load may be applied before cooling.

5.7.2 Cooling and heating may be implemented from one side on the side opposite the side on which the thermocouple is fitted, or from both sides.

5.7.3 The temperature gradient is to be controlled in the range of 0.25[^{o}C/mm] to 0.35[^{o}C/mm] in the range of width from $0.3W_s$ to $0.7W_s$ at the central part of the test specimen.

5.7.4 When the specific temperature gradient is reached, the temperature is to be maintained for more than 10 minutes, after which the specified test load may then be applied.

5.7.5 After maintaining the test load for at least 30 seconds, a brittle crack is to be generated by impact. The standard impact energy is taken as 20 to 60 [J] per 1 [mm] plate thickness. If the brittle crack initiation characteristics of the base metal are high, and it is difficult to generate a brittle crack, the impact energy may be increased to the upper limit of 120 [J] per 1 [mm] plate thickness.

5.7.6 Loading is stopped when the initiation, propagation, and arrest of crack have been confirmed. Normal temperature is restored, and if necessary, the ligament is broken by gas cutting and forcibly the specimen is broken by using the testing machine. Or, after the ductile crack has been propagated to an adequate length with the testing machine, the ligament is broken by gas cutting.

5.7.7 After forcing the fracture, photos of the fractured surface and the propagation route are to be taken, and the crack length is to be measured.

5.8 Test results

5.8.1 The distance from the top of the test specimen including the notch to the maximum length in the plate thickness direction of the arrested crack tip is to be measured. If the crack surface deviates from the surface normal to the line of load of the test specimen, the projected length on the surface normal to the line of load is to be measured. In this case, if the trace of brittle crack arrest is clearly visible on the fractured surface, the first crack arrest position is taken as the arrest crack position.

5.8.2 From the results of thermocouple measurement, the temperature distribution curve is to be plotted, and the arrest crack temperature is to be measured corresponding to the arrest crack length.

5.8.3 The brittle crack arrest toughness value (K_{ca} value) of each test is to be determined by using the following formula:

$$K_{ca}=\sigma\sqrt{\pi a}\sqrt{\left(\frac{2W_s}{\pi a}\right)\tan\left(\frac{\pi a}{2W_s}\right)}$$

5.9 Report

5.9.1 The following items are to be reported:

(i) Testing machine specifications; testing machine capacity, distance between pins (L_p)

(ii) Load jig dimensions; tab plate thickness (t_r), tab plate width (W_r), test specimen length including tab plate (L_s + 2L_r)

(iii) Test specimen dimensions; plate thickness (t_s); test specimen width (W_s) and length (L_s)

(iv) Test conditions; preload stress, test stress, temperature distribution (figure or table) impact energy

(v) Test results; crack arrest length (a_a), temperature gradient at arrest position, brittle crack arrest toughness (K_{ca})

(vi) Dynamic measurement results (if measurement is carried out); crack growth rate, strain change

(vii) Test specimen photos; fracture route, fractured surface

5.9.2 If the conditions below are not satisfied, the test results are to be treated as reference values.

(i) The brittle crack arrest position is to be in the range of the hatched part shown in Fig.5.9.1

In this case, if the brittle crack arrest position is more than 50 [mm] away from the centre of the test specimen in the longitudinal direction of the test specimen, the temperature of the thermocouple at the ±100 [mm] position is to be within ±3[^{o}C] of the thermocouple at the centre.

(ii) The brittle crack should not have a distinct crack bifurcation while it propagates.

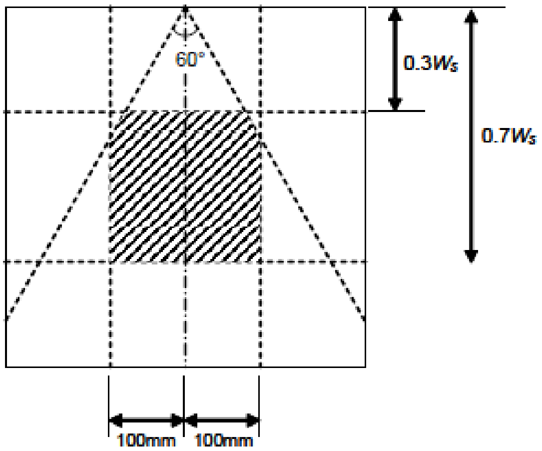


Fig. 5.9.1 Necessary conditions for arrest crack position

5.9.3 From effective test results measured at more than 3 points, the linear approximation equation is to be determined on the Arrhenius plot, and K_{ca} at the desired temperature is to be calculated. In this case, data should exist on both sides, that is, the high temperature and low temperature sides around the assessed temperature.

End of Chapter

Chapter 3

Rolled Steel Plates, Strips, Sections and Bars

Contents

Section 1

General Requirements

1.1 Scope

1.1.1 This Chapter gives general requirements for hot rolled plates, strips and sections intended for use in the construction of ships, boilers, pressure vessels and machinery structures. These requirements are also applicable to hot rolled bars, except where such materials are intended for the manufacture of bolts, shafts, etc. by machining operations only. When used for this purpose hot rolled bars are to comply with the requirements of Ch. 5.

1.2 Manufacture

1.2.1 The steel is to be manufactured at the approved works by the open hearth, electric furnace or one of the basic oxygen processes or by other processes specially approved by IRS.

The approval of the steel works is to be carried out in accordance with IRS Classification Notes: 'Approval scheme for the manufacturing process of normal and higher strength hull structural steels'.

1.2.2 The suitability of each grade of steel for forming and welding is to be demonstrated during the initial approval tests at the steel works. The type and the extent of testing required is at the discretion of IRS.

1.2.3 It is the manufacturer's responsibility to assure that effective process and production controls in operation are adhered to in accordance with the manufacturing specifications. Where control imperfection that may lead to inferior quality of product occurs, the manufacturer is to identify the cause and establish counter measure to prevent its occurrence. Also the complete investigation report is to be submitted to the Surveyor. Each affected piece considered for further usage is to be tested to the Surveyor's satisfaction.

The frequency of testing may be increased to gain confidence for subsequent products as considered necessary.

1.3 Quality of materials

1.3.1 Defects not prejudicial to the proper application of steel are not, except by special agreement, to be grounds for rejection. Where necessary, suitable methods of non-destructive examination may be used for the detection of harmful surface and internal defects. The extent of this examination, together with appropriate acceptance standards, is to be agreed between the purchaser, manufacturer and Surveyors.

1.4 Thickness tolerance of plates and wide flats with width ≥ 600 [mm]

1.4.1 The tolerance on thickness of a given product are defined as follows:

a) Minus tolerance is the lower limit of the acceptable range below the nominal thickness.

b) Plus tolerance is the upper limit of the acceptable range above the nominal thickness.

Note : Nominal thickness is defined by the purchaser at the time of enquiry and order.

1.4.2 The minus tolerance for products for normal strength, higher strength and high strength quenched and tempered steels is 0.3 [mm] irrespective of nominal thickness.

1.4.3 The minus tolerance for products intended for machinery structures are to be in accordance with Table 1.4.3.

Table 1.4.3

Nominal thickness [mm]	Minus tolerance [mm]
≥ 5 to < 8	-0.4
≥ 8 to < 15	-0.5
≥ 15 to < 25	-0.6
≥ 25 to < 40	-0.8
≥ 40	-1.0

1.4.4 The tolerance for thickness below 5 [mm] may be specially agreed.

1.4.5 The plus tolerance on nominal thickness is to be in accordance with a recognized national or international standard or as specified.

1.4.6 The tolerance on sections (except for wide flats) are to be in accordance with the requirements of recognized international or national standard.

1.4.7 The tolerance on nominal thickness are not applicable to areas repaired by grinding which are to be in accordance with a recognized standard.

1.4.8 For materials intended for applications as detailed in Sec. 5 and 6, no minus tolerance is permitted in the thickness of plates and strip.

1.4.9 The responsibility for verification and maintenance of the production within the required tolerance rests with the manufacturer. The Surveyor may require to witness some measurements.

1.4.10 The responsibility for storage and maintenance of the delivered products with acceptable level of surface conditions rests with the shipyard before the products are used in fabrication.

1.4.11 Where zero minus tolerance is applied in accordance with Class C of ISO 7452, the requirements of 1.4.12 to 1.4.14 need not be applied.

Additionally, if ISO 7452 is applied, it is required that the steel mill demonstrate to the satisfaction of IRS that the number of measurements and measurement distribution is appropriate to establish that the mother plates produced are at or above the specified nominal thickness.

1.4.12 Average thickness

1.4.12.1 The average thickness of a product or products is defined as the arithmetic mean of the measurements made in accordance with the requirements of 1.4.13.

1.4.12.2 The average thickness of a product or products for hull structural steels is not to be less than the nominal thickness.

1.4.13 Thickness measurements

1.4.13.1 The thickness is to be measured at locations of a product or products as defined in 1.4.14.

1.4.13.2 Automated method or manual method may be applied to the thickness measurements.

1.4.13.3 The procedure and the records of measurements are to be made available to the Surveyor and copies provided on request.

1.4.14 Thickness measuring locations

1.4.14.1 The requirements of 1.4.14.2 are to be applied to the thickness measuring locations for the thickness tolerance and the average thickness of the product.

1.4.14.2 At least two lines among Line 1, Line 2 or Line 3 as shown in Fig.1.4.14.2 are to be selected for the thickness measurements and at least three points on each selected line are to be selected for thickness measurement. If more than three points are taken on each line the number of points are to be equal on each line.

Note : The measurement locations apply to a product rolled directly from one slab or steel ingot even if the product is to be later cut by the manufacturer. Examples of the original measurements relative to later cut products are shown in Fig. 1.4.14.2b), It is to be noted that the examples shown are not representative of all possible cutting scenarios.

For automated methods, the measuring points at sides are to be located not less than 10 [mm] but not greater than 300 [mm] from the transverse or longitudinal edges of the product.

For manual methods, the measuring points at sides are to be located not less than 10 [mm] but not greater than 100 [mm] from the transverse or longitudinal edges of the product.

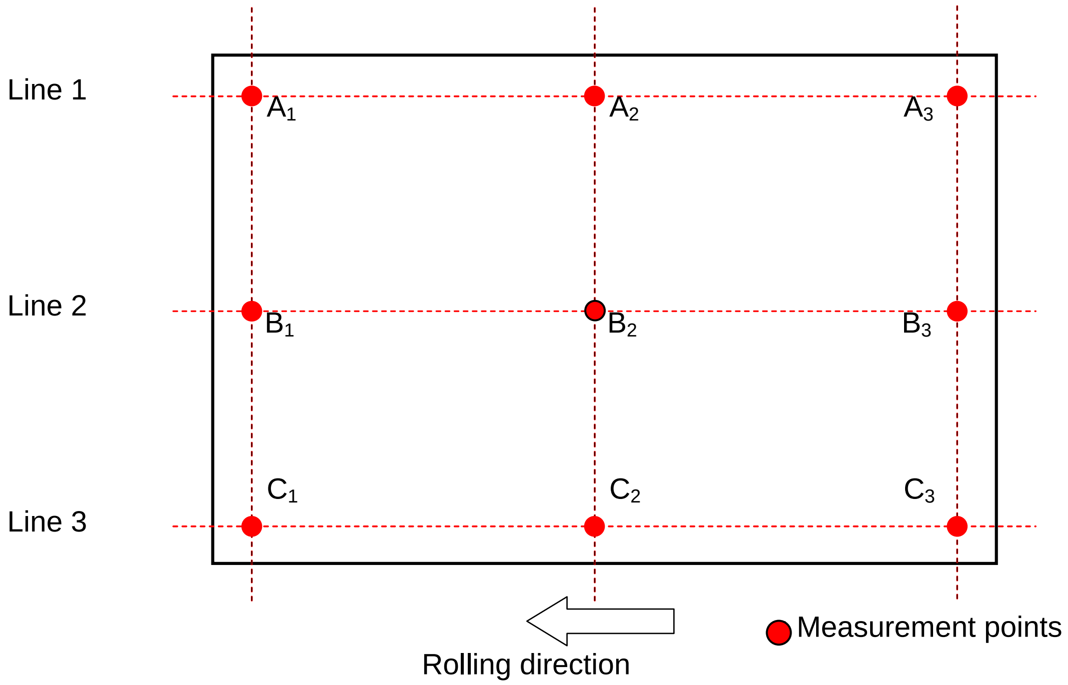
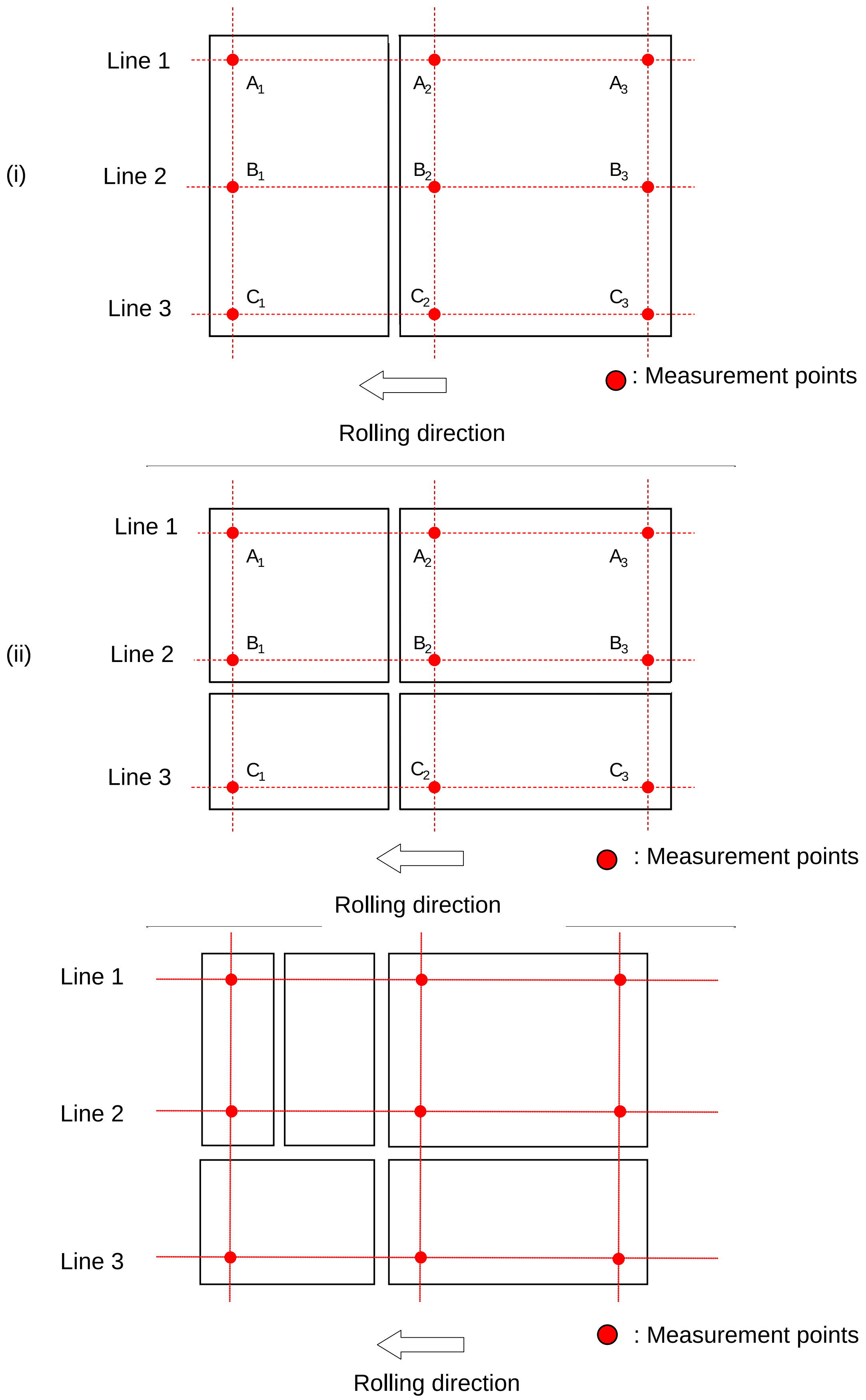


Fig. 1.4.14.2a) : Locations of Thickness Measuring Points for the Original Steel Plates

Fig. 1.4.14.2b) : Locations of Thickness Measuring Points for the Cut Steel Products



1.5 Heat treatment, condition of supply

1.5.1 All materials are to be supplied in the heat treated conditions described in the subsequent sections of this chapter unless supply in the as-rolled condition is allowed.

1.5.2 Where the material is supplied in the as rolled condition and intended for subsequent hot forming, the manufacturer is to carry out any heat treatment which may be necessary to prevent hydrogen cracking or make the material in a safe condition for transit and Surveyors are to be advised of any such heat treatment carried out. This requirement is applicable mainly to carbon and carbon-manganese steel products over 50 [mm] thick and to alloy steel products.

1.5.3 Where controlled rolling or thermo-mechanical processing is permitted as an alternative to normalising, these procedures may be used subject to full details being submitted and a test program being carried out under the supervision of the Surveyors and the test results being found satisfactory by IRS. These rolling processes are defined as follows:

(See Fig.1.5.3).

a) As rolled, AR - this procedure involves the rolling of steel at high temperature followed by air-cooling. The rolling and finishing temperatures are typically in the austenite recrystalisation region and above the normalising temperature. The strength and toughness properties of steel produced by this process are generally less than steel heat treated after rolling or than steel produced by advanced processes.

b) Normalising, N - normalising involves heating rolled steel above the critical temperature, Ac3 and in the lower end of the austenite recrystalisation region followed by air-cooling. The process improves the mechanical properties of as rolled steel by refining the grain size.

c) Controlled rolling, CR - this is a procedure in which generally the final rolling temperature is controlled within the range used for normalising heat treatments so that the austenite completely recrystallises.

d) Quenching and Tempering, QT – Quenching involves a heat treatment process in which steel is heated to an appropriate temperature above the Ac3 and then suddenly cooled with an appropriate coolant for the purpose of hardening the microstructure. Tempering subsequent to quenching is a process in which the steel is reheated to an appropriate temperature not higher than the Ac1 to restore toughness properties by improving the microstructure.

e) Thermo-mechanical Rolling, TM – Thermo-mechanical controlled processing - this is a procedure which involves the strict control of both the steel temperature and the rolling reduction. Generally a high proportion of the rolling reduction is carried out close to or below the AR3 transition temperature and may involve rolling towards the lower end of the temperature range of the inter critical duplex phase region thus permitting little if any recrystallisation of the austenite. Unlike controlled rolled (normalised rolling) the properties conferred by TM (TMCP) cannot be reproduced by subsequent normalising or other heat treatment.

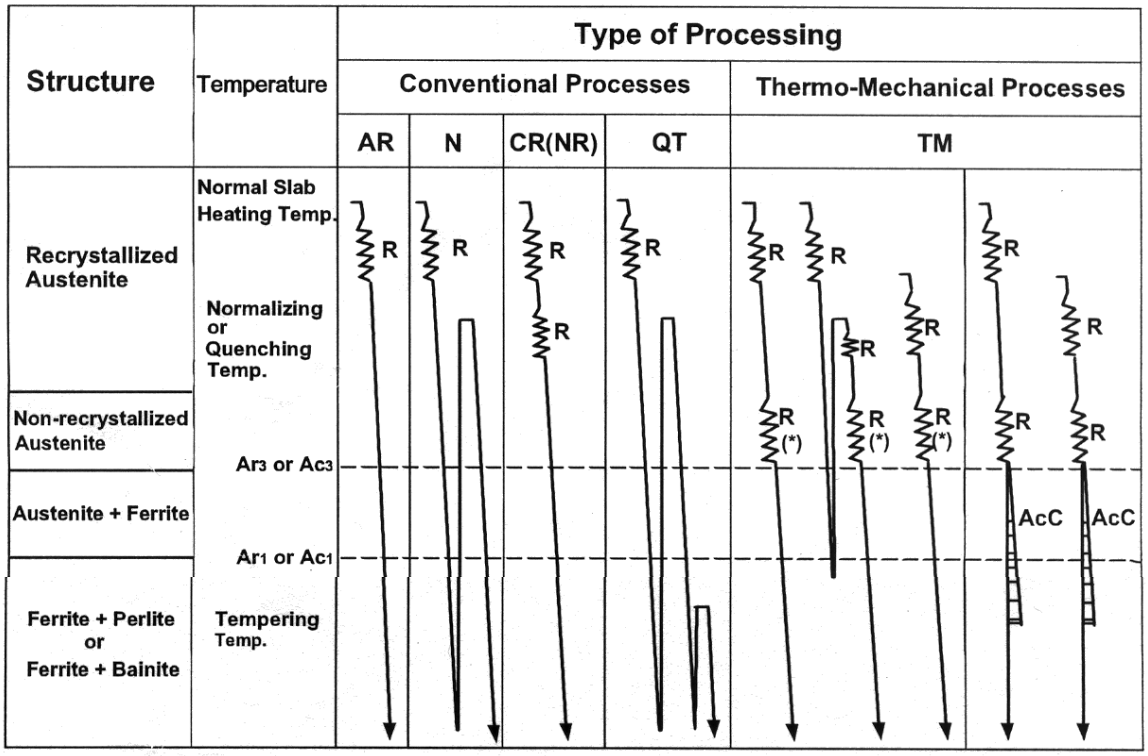
   The use of accelerated cooling on completion of TM-rolling may also be accepted subject to the special approval of IRS. The same applies for use of tempering after completion of the TM-rolling.

f) Accelerated cooling AcC - accelerated cooling is a process, which aims to improve mechanical properties by controlled cooling with rates higher than air cooling immediately after the final TM-rolling operation. Direct quenching is excluded from the accelerated cooling.

   The material properties conferred by TM and AcC cannot be reproduced by subsequent normalising or other heat treatment.

1.5.3.1 Where CR and TM with/without AcC are applied, the programmed rolling schedules are to be verified by IRS at the steel works and are to be made available when required by the attending Surveyor. On the manufacturer's responsibility, the programmed rolling schedules are to be adhered to during the rolling operation. (Refer 1.2.3). To this effect, all the records of actual rolling are to be reviewed by the manufacturer and occasionally by the Surveyor.

When deviation from the programmed rolling schedules or normalizing or quenching and tempering procedures occurs, the manufacturer shall take further measures required in 1.2.3 to the Surveyor's satisfaction.



Notes:

AR:	As Rolled
N:	Normalizing
CR(NR):	Controlled Rolling (Normalizing Rolling)
QT:	Quenching and Tempering
TM:	Thermo-Mechanical Rolling (Thermo-Mechanical Controlled Process)
R:	Reduction
(*):	Sometimes rolling in the dual-phase temperature region of austenite and ferrite
AcC:	Accelerated Cooling

Fig.1.5.3 : Schematic Diagrams of Thermo-Mechanical and Conventional Processes

1.5.3.2 The conditions of supply and the impact test requirements are detailed in subsequent sections of the Chapter.

1.6 Test material

1.6.1 All material in a batch presented for acceptance tests are to be of the same product form e.g. plates, flats, sections. etc., from the same cast and in the same condition of supply.

1.6.2 Test samples

a) The test samples are to be fully representative of the material and, where appropriate, are not to be cut from the material until heat treatment has been completed.

b) The test specimens are not to be separately heat treated in any way.

1.6.3 Unless otherwise agreed, the test samples are to be taken from the following position :

1.6.3.1 **Plates and flats with a width ≥ 600 [mm]** : The test samples are to be taken from one end at a position approximately midway between the axis in the direction of the rolling and the edge of the rolled product (See Fig.1.6.1 a). Unless otherwise agreed the tensile test specimens are to be prepared with their longitudinal axis transverse to the final direction of rolling.

1.6.3.2 **Flats with a width < 600 [mm], bulb flats and other sections** : For flats having a width of 600 [mm] or less, bulb flats and other sections the test specimens are to be taken from one end at a position approximately one third from the outer edge (See Figs.1.6.1 b,c,d), or in the case of small sections as near as possible to this position. In the case of channels, beams or bulb angles the test samples may alternatively be taken from a position approximately one quarter of the width from the web centreline or axis (See Fig.1.6.1 c). The tensile test specimens may be prepared with their longitudinal axis either parallel or transverse to the final direction of rolling.

1.6.3.3 **Bars and other similar products**: The test specimens are to be taken so that the axis of the test specimen is parallel to the direction of rolling. For small sizes, the test specimen may consist of a suitable length of the full cross section of the product (the impact test specimen receiving nevertheless the necessary machining). For larger sizes, the test samples are to be taken so that the axis of the test specimen lies as near as possible to the following :

a) for non-cylindrical sections, at one third of the half diagonal from the outside.

b) for cylindrical sections, at one third of the radius from outside (See Fig.1.6.1 e).

1.6.3.4 For plates and flats with thicknesses in excess of 40 [mm], full thickness specimens may be prepared, but when instead a machined round specimen is used then the axis is to be located at a position lying one-quarter of the product thickness from the surface as shown in Fig.1.6.1.f.

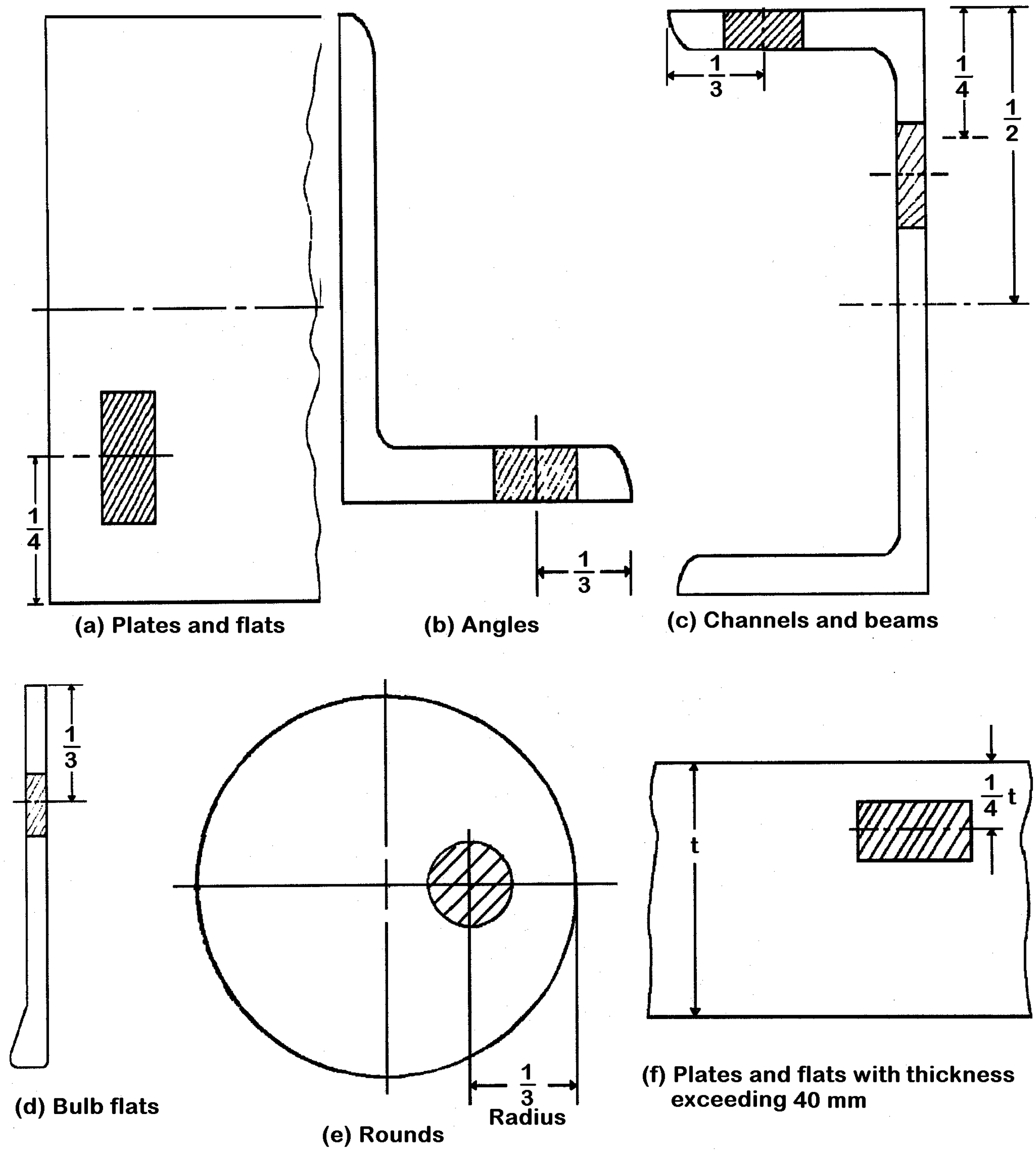


Fig.1.6.1 : Samples for testing

1.7 Mechanical test specimens

1.7.1 The tensile test specimens are to be machined to the dimensions detailed in Ch. 2.

1.7.2 Impact test specimens: The impact test specimens are to be of the charpy V-notch type machined to the dimensions detailed in Ch. 2 and cut with their longitudinal axis either parallel or transverse to the final direction of rolling of the material. They are to be taken from a position close to one of the rolled surfaces, except that for plates and sections over 40 [mm] thick the axis of test specimens are to be one quarter of the thickness from one of the rolled surfaces. For bars and other similar products the axis of the test specimens are to be as specified in 1.6.3.3. The notch is to be cut in a face of the test specimen which was originally perpendicular to the rolled surface. The position of the notch is to be not nearer than 25 [mm] to a flame-cut or sheared edge.

1.8 Surface inspection and dimensions

1.8.1 Surface inspection and verification of dimensions are the responsibility of the steel-maker, and acceptance by the Surveyors of material later found to be defective shall not absolve the steel maker from this responsibility. The manufacturer is also responsible for compliance with the general requirements concerning freedom from harmful internal defects.

1.9 Freedom from defects

1.9.1 All products must have a workmanlike finish and must be free from defects and imperfections which may impair their proper workability and use. This may however, include some discontinuities of a harmless nature, minor imperfections e.g. pittings, rolling in scale, indentations, roll marks, scratches and grooves which cannot be avoided completely despite proper manufacturing and which will not be objected to provided they do not exceed the acceptable limits contained herein.

1.9.2 **Imperfections** : Notwithstanding this, the products may have imperfections exceeding the discontinuities inherent to the manufacturing process, as defined under 1.9.1. In such cases, limits for their acceptability are to be agreed with IRS, taking the end use of the product into consideration.

1.9.3 **Defects** : Cracks, shells, sand patches and sharp edged seams are always considered defects which would impair the end use of the product and which require rejection or repair, irrespective of their size and number. The same applies to other imperfection exceeding the acceptable limits.

1.10 Repairs

1.10.1 Surface defects in structural steel may be removed by local grinding, provided that

a) the nominal product thickness will not be reduced by more than 7 per cent or 3 [mm], whichever is the less.

b) each single ground area does not exceed 0.25 [m^2].

c) each single ground area does not exceed 2 per cent of the total surface in question.

   Ground areas lying in a distance less than their average breadth to each other are to be regarded as one single area.

d) Ground area lying opposite each other on both surfaces must not decrease the product thickness by values exceeding the limits as stated above in a, b and c.

e) the ground area must have smooth transition to the surrounding surface of the product. Ground areas lying in a distance less than their average breadth to each other are to be regarded as one single area. The repairs are to be agreed with the Surveyor in each case and are to be carried out under his supervision unless otherwise agreed. Complete elimination of the defects may be verified by a magnetic particle or dye penetrant test procedure at the Surveyors' discretion.

f) Where necessary the entire surface may be ground to a depth as given by the under thickness tolerances of the product.

1.10.2 Surface defects which cannot be dealt with as in 1.10.1 may be repaired by chipping and/ or grinding followed by welding subject to Surveyor's consent and under his supervision provided:

a) And single welded area shall not exceed 0.125 [m] and the sum of all areas shall not exceed 2 per cent of the surface side in question. The distance between two welded areas is not to be less than their average width.

b) The weld preparation must not reduce the thickness of the product below 80 per cent of the nominal thickness. For occasional defects with depths exceeding the 80 per cent limit, special consideration at the Surveyors' discretion will be necessary.

c) The repair shall be carried out by qualified welders using an approved procedure for the appropriate steel grade. The electrodes shall be of low hydrogen type and must be dried in accordance with manufacturer's requirements and protected against rehumidification before and during welding.

d) The welds are to be of reasonable length and must have at least 3 parallel welding beads. The deposited metal must be sound without any lack of fusion, undercut, cracks and other defects which could impair the workability or use of the product. Welding is to be performed with one layer of beads in excess of which is subsequently to be ground smooth to the surface level.

e) Products which are to be supplied in a heat treated condition are to be welded prior to the heat treatment; otherwise, a new heat treatment may be required.

f) Products supplied in the controlled rolled or as rolled condition may require a suitable heat treatment after welding. however, the post weld heat treatment may be omitted provided the manufacturer has demonstrated by a procedure test that the required properties will be maintained without heat treatment.

g) For every welding repair the manufacturer must provide the Surveyor with a written report and a sketch showing sizes and location of the defects and full details of the repair procedure including the welding consumables, post weld heat treatment and non-destructive testing.

1.10.3 Cracks, shells, sand patches and sharp edged seams are always considered defects which would impair the end use of the product and which require rejection or repair, irrespective of their size and number. The same applies to other imperfections exceeding the acceptable limits.

1.11 Special quality plate material ('z' quality)

1.11.1 When plate material, intended for welded construction, will be subject to significant strains in a direction perpendicular to the rolled surfaces, it is recommended that consideration be given to the use of special plate material with specified through thickness properties. These strains are usually associated with thermal contraction and restraint during welding, particularly for full penetration "T"- butt welds, but may also be associated with loads applied in service or during construction. Requirements for these materials are detailed in Sec. 8 and it is the responsibility of shipbuilder or fabricator to make provision for the use of this material.

1.12 Branding of materials

1.12.1 Every finished item is to be clearly marked by the manufacturer in at least one place with IRS brand IR and the following particulars:

a) The manufacturer's name or trade mark;

b) Identification mark for the grade of steel, (material supplied in the thermo-mechanically controlled process condition is to have the letter TM added after the identification mark) ;

c) Cast or identification number and/or initials which enable the full history of the item to be traced;

d) If required by the purchaser, his order number or other identification marks.

e) Steels, which have been specially approved and which differ from the requirements given in this Chapter are to have the letter "S" marked after the agreed identification mark.

f) Steel plates that have complied with the requirements for corrosion resistant steel will be identified by adding a corrosion designation to the unified identification mark for the grade of steel. The corrosion resistant steel is to be designated according to its area of application as follows:

- Lower surface of strength deck and surrounding structures; **RCU**

- Upper surface of inner bottom plating and surrounding structures; **RCB**

- For both strength deck and inner bottom plating; **RCW**

1.12.2 Products complying with the requirements of Sec. 8 are to be marked "Z 25" or 'Z 35' as appropriate, in addition to the material grade designation e.g. 'EH36Z25' or 'EH36Z35'.

1.12.3 The above particulars, but excluding the manufacturer's name or trade mark where this is embossed on finished products, are to be encircled with paint or otherwise marked so as to be easily recognizable.

1.12.4 In the event of any material bearing IRS brand failing to comply with the test requirements, the brand name is to be unmistakably defaced.

1.13 Test certificates or shipping statements

1.13.1 The Surveyor is to be supplied, in duplicate, copies of the test certificates or shipping statements for all accepted materials, IRS may require separate documents for each grade of steel. These documents are to contain, in addition to the description, dimensions, etc. of the material at least the following particulars:

a) Purchaser's order number and if known the ship number for which the material is intended;

b) Identification number and/or initials;

c) Identification of steel works;

d) Identification of the grade of steel;

e) Cast number and ladle analysis;

f) For steel with a corrosion resistant steel designation the weight percentage of each element added or intentionally controlled for improving corrosion resistance.

g) Condition of supply when other than as rolled e.g. normalized or controlled rolled;

h) If the material is of rimming quality, this should be stated;

i) Test results.

In the case of 'Z' quality steel, notation 'Z25' or 'Z35' as appropriate, is to be indicated with the steel grade and test results are to include through thickness reduction in area (%).

1.13.2 Before the test certificates or shipping statements are signed by the Surveyor, the manufacturer is required to furnish him with a written declaration stating that the material has been made by an approved process and that it has been subjected to and has withstood satisfactorily the required tests in the presence of the Surveyor or his authorized deputy. The following form of declaration will be accepted if stamped or printed on each test certificate or shipping statement with the name of steelworks and initialed by the makers or an authorized deputy:
"We hereby certify that the material has been made by an approved process in accordance with the Rules of Indian Register of Shipping and has been tested satisfactorily in the presence of the surveyors of Indian Register of Shipping".

1.13.3 When steel is not produced at the works at which it is rolled a certificate is to be supplied to the Surveyor at the rolling mill stating the process by which it was manufactured and the name of the manufacturer, the number of cast from which it was made and the ladle analysis. The Surveyors are to have access to the works at which the steel was produced and the works must be approved by IRS.

Section 2

Normal Strength Steels for Ship Structures

2.1 General

2.1.1 Normal strength hot-rolled steel plates, wide flats, sections and bars intended for use in hull construction, is to comply with the following requirements. Steel differing in chemical composition, deoxidation practice, heat treatment or mechanical properties may be accepted, subject to special agreement by IRS.

2.1.2 These requirements are primarily intended to apply to steel plates not exceeding 100 [mm] in thickness and sections and bars not exceeding 50 [mm] in thickness. For greater thickness, certain variations in the requirements may be allowed or required in particular cases after consideration of the technical circumstances involved.

2.1.3 Additional approval tests may be required to verify the suitability for forming and welding of Grade E plate exceeding 50 [mm] in thickness.

2.2 Deoxidation and chemical composition

2.2.1 The method of deoxidation and the chemical composition of ladle samples are to comply with the requirements of Table 2.2.1.

2.2.2 When any grade of steel is supplied in the thermo-mechanically controlled processed condition, deviations in the specified chemical composition may be allowed by IRS.

2.3 Heat treatment, condition of supply

2.3.1 All materials are to be supplied in a condition complying with Table 2.3.1 and Table 2.3.2. Where alternative arrangements are permitted these are at the option of the steelmaker, unless otherwise expressly stated in the order for the material.

2.4 Mechanical tests

2.4.1 Sizes and orientation of test specimens are to be in Accordance with the requirements of Sec. 1.

Table 2.2.1 : Deoxidation and chemical composition

Grade	A	B	D	E
Deoxidation practice	Any method[1]	Any method except rimmed steel	For t ≤ 25 [mm] killed, For t > 25 [mm] fully killed and fine grain treated[2]	Fully killed fine grain treated
Chemical composition per cent [6,7,8]				
Carbon max.	0.21[4]	0.21	0.21	0.18
Manganese min	2.5 x Carbon %	0.80[5]	0.60	0.70
Silicon max	0.50 max.	0.35 max.	0.35 max.	0.10 - 0.35
Phosphorus max	0.035 max.	0.035 max.	0.035 max.	0.035 max.
Sulphur max	0.035 max.	0.035 max.	0.035 max.	0.035 max.
Aluminium (acid soluble)[3]	-	-	0.015[2]	0.015
Carbon + 1/6 of the manganese content is not to exceed 0.40 per cent				

Notes :

1 For grade A, rimmed steel may be accepted upto 12.5 [mm] thick inclusive provided that it is stated on the test certificates or shipping statements to be rimmed steel and is not excluded by the purchaser's order.
2 Aluminium is required for thickness above 25 [mm].
3 The total aluminium content may be determined instead of the acid soluble content. In such cases the total aluminium content is to be not less than 0.020 per cent.
4 Max. 0.23% for sections.
5 For grade B, when the silicon content is 0.10% or more (killed steel), the minimum manganese content may be reduced to 0.60%.
6 IRS may limit the amount of residual/trace elements which may have an adverse effect on the working and use of the steel, e.g. copper and tin.
7 Where additions of any other element have been made as part of the steelmaking practice, the content is to be specified.
8 When any grade of steel is supplied in the thermo-mechanically rolled condition, variation in the specified chemical composition may be allowed or required by IRS.

Table 2.3.1 : Condition of supply for normal strength steel (1)

Grades	Thickness	Condition of supply
A	≤ 50 mm	Any
	> 50 mm ≤ 100 mm	Normalized, controlled rolled or thermo-mechanically rolled (2)
B	≤ 50 mm	Any
	> 50 mm ≤ 100 mm	Normalized, controlled rolled or thermo-mechanically rolled (2)
D	≤ 35 mm	Any
	> 35 mm ≤ 100 mm	Normalized, controlled rolled or thermo-mechanically rolled (3)
E	≤ 100 mm	Normalized or thermo-mechanically rolled (3)

Table 2.3.1 Notes:

1) These conditions of supply and the impact test requirements are summarised in Table 2.3.2

2) Subject to the special approval of IRS, Grades A and B steel plates may be supplied in the as rolled condition.

3) Subject to the special approval of IRS, sections in Grade D steel may be supplied in the as rolled condition provided satisfactory results are consistently obtained from Charpy V-notch impact tests. Similarly sections in Grade E steel may be supplied in the as rolled or controlled rolled condition. For the frequency of impact tests see 2.4.4, 2.4.5, 2.4.6 and 2.4.7.

2.4.2 For each batch presented. except where specially agreed by IRS. one tensile test is to be made from one piece unless the weight of finished material is greater than 50 tonnes in which case one extra test piece is to be made from a different piece from each 50 tonnes or fraction thereof. Additional tests are to be made for every variation of 10 [mm] in thickness of plate or diameter of products from the same cast. For sections the thickness to be considered is the thickness of the product at the point at which samples are taken for mechanical tests.

2.4.3 For plates of thickness exceeding 50 [mm] in Grade E steel, one tensile test is to be made on each piece.

2.4.4 For each batch presented, except where specially agreed by IRS at least one set of three Charpy V-notch test specimens is to be made from one piece unless the weight of finished material is greater than 50 tonnes in which case one extra set of three test specimens is to be made from a different piece from each 50 tonnes or fraction thereof. The piece selected for the preparation of test specimen is to be the thickest of each batch. Where steel plates except for Grade 'A' steel over 50 [mm] in thickness is supplied in the controlled rolled condition, the frequency of impact test is to be made from a different piece from each 25 tonnes or fraction thereof.

2.4.5 When subject to the special approval of IRS, material is supplied in the as rolled condition the frequency of impact tests is to be increased to one set from each batch of 25 tonnes or fraction thereof. However, for Grade 'A' steel over 50 [mm] thickness when supplied in the "as rolled" condition, one set of three charpy V-notch test specimens may be taken from each batch of 50 tonnes or fraction thereof.

2.4.6 For plates in Grade E steel, one set of three impact test specimens is to be made from each piece.

2.4.7 For Grade E sections, except where specially agreed, for each batch presented, one set of three impact test specimens is to be made for each 25 tonnes of normalised material and for each 15 tonnes of materials which are not normalised.

2.4.8 Results of mechanical testing are to comply with Table 2.4.1. For impact tests, one individual value may be less than the required average value provided that it is not less than 70 per cent of this average value. *See also Ch.* 1.

2.4.9 Minimum average energy values are specified for Charpy V-notch impact test specimens taken in either the longitudinal or transverse directions.

Generally only longitudinal test specimens need be prepared and tested except for special applications where transverse test specimens may be required. Transverse test results are to be guaranteed by the manufacturer. The tabulated values are for standard specimens 10 [mm] x 10 [mm]. For plate thicknesses lower than 10 [mm], sub-size specimens may be used with reduced requirements as follows :

Specimen 10 x 7.5 [mm] : 5/6 of tabulated energy
Specimen 10 x 5 [mm] : 2/3 of tabulated energy.

Table 2.3.2 : Required condition of supply and number of impact tests for normal strength steels

Grade	Deoxidation Practice	Pro-ducts	Condition of supply (batch for impact tests) (1)(2)			
			Thickness [mm]			
			10 12.5 20 25 30 35 40 50 100			
A	Rimmed	Sections	A(-)	Not applicable		
A	For t ≤ 50 mm Any method except rimmed For t > 50 mm Killed	Plates	A(-)	N(-) TM(-) CR(50), AR*(50)		
A		Sections	A(-)	Not applicable		
B	For t ≤ 50 mm Any method except rimmed For t > 50 mm Killed	Plates	A(-)	A(50)	N(50) TM(50) CR(25), AR*(25)	
B		Sections	A(-)	A(50)	Not applicable	
D	Killed	Plates Sections	A(50)	Not applicable		
D	Plates Killed and fine grain treated	Plates	A(50)	N(50) CR(50) TM(50)	N(50) TM(50) CR(25)	
D		Sections	A(50)	N(50) CR(50) TM(50) AR*(25)	Not applicable	
E	Killed and fine grain treated	Plates	N(Each piece) TM(Each piece)			
E		Sections	N(25) TM(25) AR*(15), CR*(15)	Not applicable		

Remarks:

1. Condition of Supply

A - Any (Not Specified)
N - Normalised Condition
CR - Controlled Rolled Condition
TM - Thermo-Mechanical Rolling
AR* - As Rolled Condition subject to special approval of IRS
CR* - Controlled Rolled Condition subject to special approval of IRS.

2. Number of Impact Tests

One set of impact tests is to be taken from each batch of the specified weight in ( ) in tones or fraction thereof.

Table 2.4.1 : Mechanical properties for normal strength steels

Grade	**Yield strength ReH [N/mm^2] min.**	**Tensile strength Rm [N/mm^2]**	**Elongation $5.65\sqrt{S_o}$ A5 (%)**	**Impact Test**						
				Test Temp. °C	**Average impact energy (J) min.**					
					t ≤ 50 mm		**50 < t ≤ 70 mm**		**70 < t ≤ 100 mm**	
					Long (3)	Trans (3)	Long (3)	Trans (3)	Long (3)	Trans (3)
A	235	400/520 (1)	22(2)	+20	-	-	34(5)	24(5)	41(5)	27(5)
B				0	27(4)	20(4)	34	24	41	27
D				-20	27	20	34	24	41	27
E				-40	27	20	34	24	41	27

Notes:

1) For all thicknesses of Grade A sections the upper limit for the specified tensile strength range may be exceeded at the discretion of IRS.

2) For full thickness flat tensile test specimens with a width of 25 mm and a gauge length of 200 mm the elongation is to comply with the following minimum values:

Thickness [mm]		> 5	> 10	> 15	> 20	> 25	> 30	> 40
	≤ 5	≤ 10	≤ 15	≤ 20	≤ 25	≤ 30	≤ 40	≤ 50
Elongation	14	16	17	18	19	20	21	22

3) See 2.4.9.

4) Charpy V-notch impact tests are generally not required for Grade B steel with thickness of 25 mm or less.

5) Impact tests for Grade A over 50 mm thick are not required when the material is produced using fine grain practice and furnished normalised. TM rolling may be accepted without impact testing at the discretion of IRS.

Section 3

Higher Strength Steels for Ship Structures

3.1 General

3.1.1 Higher strength steel, supplied in three strength levels, 32, 36 and 40, intended for use in hull construction, is to comply with following requirements.

Steel differing in chemical composition, deoxidation practice, heat treatment or mechanical properties may be accepted, subject to special approval by IRS. Such steel is to be given special designation.

3.1.2 Each strength level is subdivided into four grades, AH, DH, EH and FH differing in the required levels of notch toughness.

3.1.3 The requirements of this section are primarily intended to apply to plates not exceeding 100 [mm] in thickness in general, and sections and bars not exceeding 50 [mm] in thickness. For greater thickness, these requirements may be applied with certain variations, as may be agreed by IRS.

The additional requirements for high strength plates having specified minimum yield point of 460 [N/mm^2] with thickness over 50 [mm] and not greater than 100 [mm] for use in longitudinal structural members in the upper deck region of container ships (such as hatch side coaming, hatch coaming, hatch coaming top and attached longitudinal) and denoted by Grade EH47 are also given in this section.

3.1.4 It should be noted that when fatigue loading is present, the effective fatigue strength of a welded construction of higher strength steels may not be greater than that of a construction fabricated from the normal strength steels. Precautions against corrosion fatigue may also be necessary.

Note: Before subjecting steels produced by thermo-mechanical rolling to further heating for forming or stress relieving or using high heat-input welding, special consideration must be given to the possibility of a consequent reduction in mechanical properties.

3.2 Deoxidation and chemical composition

3.2.1 The method of deoxidation and chemical analysis of ladle samples are to comply with the requirements of Table 3.2.1.

The chemical composition of EH 47 steel plates would be specially considered.

Table 3.2.1 : Chemical composition and deoxidation practice for higher strength steels

Grade[1)]	**AH32/DH32/EH32 AH36/DH36/EH36 AH40/DH40/EH40**	**FH32 FH36 FH40**
Deoxidation practice	Fully killed and fine grain refined	
Chemical Composition per cent (Ladle sample)[2)]		
C max. Mn Si max. P max. S max.	0.18 0.90 - 1.60[3)] 0.50 0.035 0.035	0.16 0.90 - 1.60 0.50 0.025 0.025
Grain refining elements[5)]		
Al (acid soluble) min.	0.015[4)]	
Nb V Ti max. Total (Nb + V + Ti)	0.02 - 0.05 0.05 - 0.10 0.02 0.12 max.	
Residual elements		
Cu max. Cr max. Ni max. Mo max.	0.35 0.20 0.40 0.08	0.35 0.20 0.80 0.08

Notes:

1) The number following the grade designation indicates the yield point to which the steel is ordered or produced in [Kg/mm^2].

2) Where additions of any other element have been made as part of the steel making practice, the content is to be indicated.

3) For thickness upto and including 12.5 [mm] the minimum manganese content may be reduced to 0.70 percent.

4) The total aluminium content may be determined instead of the acid soluble content. In such cases the total aluminium content is to be not less than 0.020 percent

5) The steel is to contain aluminium, niobium, vanadium or other suitable grain refining elements, either single or in combination. When used singly the steel is to contain the specified minimum content of the grain refining element. When used in combination, the specified minimum content of atleast one refining element is applicable.

3.2.2 When required, the carbon equivalent value is to be calculated from the ladle analysis using the following formula.

$$\text{Carbon eq.} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \ \%$$

Note: This formula is applicable only to steels which are basically of the carbon manganese type and gives a general indication of the weldability of the steel.

3.2.3 Slight deviations in chemical composition with respect to Grade E36 for plates exceeding 50 [mm] may be permitted provided that these deviations are documented and approved in advance by IRS.

3.2.4 Where additions of any other element have been made as a part of the steel making practice, the content is to be indicated.

3.2.5 When any grade of higher strength steel is supplied in the thermo-mechanically controlled processed condition variations in the specified chemical composition may be allowed or required by lRS.

3.2.5.1 For TM (TMCP) steels the following special requirements apply:

j) The carbon equivalent value is to be calculated from the ladle analysis using the following formula and to comply with the requirements of the following table:

Carbon equivalent for higher strength steels upto 100 mm in thickness produced by TM		
Grade	**Carbon equivalent**	**Max. (%)[1)]**
	t ≤ 50	**50 < t ≤ 100**
AH32, DH32, EH32, FH32	0.36	0.38
AH36, DH36, EH36, FH36	0.38	0.40
AH40, DH40, EH40, FH40	0.40	0.42
EH47	NA	0.49
t = thickness [mm]		
Note: 1) It is a matter for the manufacturer and shipbuilder to mutually agree in individual cases as to whether they wish to specify a more stringent carbon equivalent.		

$$\text{Carbon eq.} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \ \%$$

ii) Other means such as cold cracking susceptibility P_{cm}, may be considered instead of the carbon equivalent for evaluating the weldability.

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

3.2.5.2 The carbon equivalent of EH47 grade steel calculated as per 3.2.2 is not to exceed 0.49%. The cold cracking susceptibility P_{cm} calculated using the formula mentioned in 3.2.5.1.(ii) is not to exceed 0.22%.

3.3 Heat treatment, condition of supply

3.3.1 All materials are to be supplied in a condition complying with the requirements given in Table 3.3.1. Where alternative conditions are permitted, these are at the option of the steelmaker, unless otherwise expressly stated in the order for material.

3.4 Mechanical tests

3.4.1 Sizes and orientation of test specimens are to be in accordance with the requirements of Sec. 1.

3.4.2 For each batch presented, except where specially agreed by IRS, one tensile test is to be made from one piece unless the weight of finished material is greater than 50 tonnes in which case one extra test piece is to be made from a different piece from each 50 tonnes or fraction thereof. Additional tests are to be made for every variation of 10 [mm] in thickness of plate or diameter of products from the same cast. For sections, the thickness to be considered is the thickness of the product at the point at which samples are taken for mechanical tests.

3.4.3 For plates of thickness exceeding 50 [mm] in Grade E steel, one tensile test is to be made on each piece.

3.4.4 For each batch of plates presented, (except for Grades EH32, EH36, EH40, EH47, FH32, FH36 and FH40) the number of Charpy V-notch impact tests is to be as follows :

i) Except where otherwise specified or specially agreed by IRS, for each batch presented, at least one set of three Charpy V-notch impact test specimens is to be made from one piece unless the weight of finished material is greater than 50 tonnes, in which case one extra set of three test specimens is to be made from a different piece from each 50 tonnes or fraction thereof.

ii) For steel plates of Grades AH40 and DH40 with thickness over 50 [mm] in normalized or TM condition, one set of impact test specimens is to be taken from each batch of 50 tonnes or fraction thereof. For those in QT condition, one set of impact test specimens is to be taken from each length as heat treated.

iii) When, subject to special approval of IRS, material is supplied in the as rolled condition, the frequency of impact tests is to be increased to one set from each batch of 25 tonnes or fraction thereof.

iv) The piece selected for the preparation of test specimens is to be the thickest in each batch.

3.4.5 For each batch of Grade EH32, EH36, EH40 and EH47 steel presented, the number of Charpy V- notch impact tests is to be as follows:

i) For plates one set of three Charpy V-notch impact test specimens is to be taken from each piece.

ii) For sections one set of impact tests is to be taken from each batch of 25 tonnes or fraction thereof.

iii) When, subject to special approval of IRS, sections are supplied in the as-rolled condition, one set of impact tests is to be taken from each batch of 15 tonnes or fraction thereof.

iv) For (ii) and (iii) above the piece selected for the preparation of test specimens is to be the thickest in each batch.

Table 3.3.1 : Required condition of supply and number of impact tests for higher strength steels

Grade	Deoxi-dation Practice	Grain Refining Elements	Pro-ducts	Condition of supply (batch for impact tests) (1)(2)				
				Thickness [mm]				
				10 – 12.5	12.5 – 20	20 25 30 35	40	50 100
AH32 AH36	Killed and fine grain treated	Nb and/or V	Plates	A(50)			N(50) CR(50),TM(50)	N(50), CR(25), TM(50)
			Sections	A(50)			N(50) CR(50),TM(50) AR*(25)	Not applicable
		Al alone or with Ti	Plates	A(50)		AR*(25)		Not applicable
							N(50), CR(50) TM(50)	N(50), CR(25) TM(50)
			Sections	A(50)			N(50) CR(50) RM(50) AR*(25)	Not applicable
AH40	Killed and fine grain treated	Any	Plates	A(50)			N(50) CR(50) TM(50)	N(50) TM(50) QT(Each length as heat treated)
			Sections	A(50)			N(50) CR(50) TM(50)	Not applicable
DH32 DH36	Killed and fine grain treated	Nb and/or V	Plates	A(50)			N(50) CR(50),TM(50)	N(50), CR(25), TM(50)
			Sections	A(50)			N(50) CR(50),TM(50) AR*(25)	Not applicable
		Al alone or with Ti	Plates	A(50)		AR*(25)		Not applicable
							N(50), CR(50) TM(50)	N(50), CR(25) TM(50)
			Sections	A(50)			N(50) CR(50) RM(50) AR*(25)	Not applicable
DH40	Killed and fine grain treated	Any	Plates	N(50) CR(50) TM(50)				N(50) TM(50) QT(Each length as heat treated)
			Sections	N(50) CR(50) TM(50)				Not applicable
EH32 EH36	Killed and fine grain treated	Any	Plates	N(Each piece) TM(Each piece)				
			Sections	N(25) TM(25) AR*(15) CR*(15)				Not applicable
EH40	Killed and fine grain treated	Any	Plates	N(Each piece) TM(Each piece) QT(Each length as heat treated)				
			Sections	N(25) TM(25) QT(25)				Not applicable

Table 3.3.1 : (Contd.)

Grade	**Deoxi-dation practice**	**Grain refining elements**	**Products**	**Condition of supply (Batch for impact tests (1)(2)**	
				Thickness [mm] 10 12.5 20 25 30 35 40 50	100
FH32 FH36	Killed and fine grain treated	Any	Plates	N(Each piece) TM(Each piece) QT(Each length as heat treated)	Not applicable
			Section	N(25) TM(25) QT(25) CR*(15)	Not applicable
FH40	Killed and fine grain treated	Any	Plates	N(Each piece) TM(Each piece) QT(Each length as heat treated)	Not applicable
			Sections	N(25) TM(25) QT(25)	Not applicable

Remarks

1. Condition of Supply

A - Any (Not Specified)

N - Normalised Condition

CR - Controlled Rolled Condition

TM - Thermo-Mechanical Rolling

QT - Quenched and Tempered Condition

AR* - As Rolled Condition subject to special approval of IRS

CR* - Controlled Rolled Condition subject to special approval of IRS.

2. Number of Impact Tests

One set of impact tests is to be taken from each batch of the "specified weight" in ( ) in tones or fraction thereof.

For Grades A32 and A36 steels charpy impact tests are not generally required provided that satisfactory results are obtained from occasional check tests selected by the Surveyor.

3.4.6 Mechanical Tests for EH47 grade steel

3.4.6.1 The following conditions also have to be met for EH47 steel in addition to the conditions mentioned in 3.4.1 to 3.4.5 for the Charpy V-notch impact test.

- Test samples are to be taken from the plate corresponding to the top of the ingot, unless otherwise agreed.
- In case of continuous castings, test samples are to be taken from a randomly selected plate.
- The location of the test sample is to be at the square cut end of the plate, approximately one quarter width from an edge, as shown in Fig 3.4.6.1.

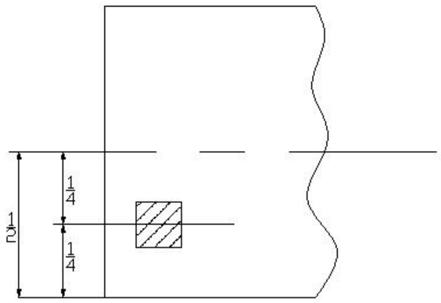


Fig.3.4.6.1: Location of Test Sample

- Samples are to be taken with respect to the principal rolling direction of the plate at the locations representing the top and the bottom of the plate as follows:
  - Longitudinal Charpy V-notch impact test: top and bottom.
  - Transverse Charpy V-notch impact test: Top only.
  - Strain Aged longitudinal Charpy V-notch impact test : Top only
- Charpy V-notch impact tests are required from both the quarter and mid thickness locations of the test samples.
- The Charpy V-notch impact test temperature is to be -40^{o}C.
- In addition to the determination of the energy value, the lateral expansion and percentage crystallinity are also to be reported.
- The strain aged samples are to be strained to 5% followed by heating to 250^{o}C prior to testing.
- Additionally at each location, Charpy V-notch impact tests are to be carried out with appropriate temperature intervals to properly define the full transition range.

3.4.6.2 The Deep Notch Test or Crack Tip Opening Displacement (CTOD) test is to be carried out. The test method and results are to be acceptable to IRS.

3.4.6.3 The Naval Research Laboratory (NRL) drop weight test is to be carried out in compliance with ASTM E208 or equivalent method.
Nil Ductility Transition Temperature (NDTT) is to be reported for reference.

3.4.6.4 The Brittle crack arrest test (standard ESSO test) as given in Pt.2, Ch.2, Sec.5 is to be carried out in order to obtain the brittle crack arrest toughness for reference.

3.4.7 Weldability Tests for EH47 grade steel

3.4.7.1 Charpy V-notch Impact test

- Charpy V-notch Impact tests are to be taken at a position of ¼ thickness from the plate surface on the face side of the weld with the notch perpendicular to the plate surface.
- One set of the specimens transverse to the weld is to be taken with the notch located at the fusion line and at a distance 2.5 and minimum 20 [mm] from the fusion line.
- The fusion boundary is to be identified by etching the specimen with a suitable reagent.
- One additional set of specimens is to be taken from the root side of the weld with the notch located at the same position and at the same depth as for the face side.
- The impact test temperature is -40^{o}C.
- Additionally at each location, impact tests are to be carried out with appropriate temperature intervals to properly define the full transition range.

3.4.7.2 Y-shape weld crack test (Hydrogen Crack Test) has to be conducted in accordance with recognized international standards such as ISO 3690.

3.4.7.3 Brittle fracture initiation test (CTOD) or deep notch test is to be carried out.
The test method and results are to be acceptable to IRS.

3.4.8 One set of Charpy V-notch impact test specimens are to be tested from each rolled length for Grades FH32, FH36 and FH40 of steel plates supplied in the normalised or thermo-mechanically controlled process condition.

3.4.9 For steels in the quenched and tempered condition, one tensile and one set of three Charpy V- notch impact tests are to be made on each plate as heat treated.

3.4.10 Generally only longitudinal (L) impact test specimens need be prepared and tested. however in all cases transverse (T) test results are to be guaranteed by the manufacturer.

3.4.11 The results of all tensile tests and the average energy value from each set of three impact tests are to comply with the appropriate requirements given in Tables 3.4.1 and Table 3.4.2.

3.4.12 When standard subsidiary impact specimens are necessary (See Ch. 2).

Table 3.4.1 : Mechanical properties for higher strength steels

Grade	Yield strength ReH [N/mm²] min.	Tensile strength Rm [N/mm²]	Elongation 5.65 $\sqrt{S_o}$ A5 (%)	Impact Test						
				Test Temp. °C	Average impact energy (J) min.					
					t ≤ 50 mm		50 < t ≤ 70 mm		70 < t ≤ 100 mm	
					Long (2)	Trans (2)	Long (2)	Trans (2)	Long (2)	Trans (2)
AH32	315	440/570	22(1)	0	31(3)	23(3)	38	26	46	31
DH32				-20	31	22	38	26	46	31
EH32				-40	31	22	38	26	46	31
FH32				-60	31	22	38	26	46	31
AH36	355	490/630	21(1)	0	34(3)	24(3)	41	27	50	34
DH36				-20	34	24	41	27	50	34
EH36				-40	34	24	41	27	50	34
FH36				-60	34	24	41	27	50	34
AH40	390	510/660	20(1)	0	39	27	46	31	55	37
DH40				-20	39	27	46	31	55	37
EH40				-40	39	27	46	31	55	37
FH40				-60	39	27	46	31	55	37

t = thickness [mm]

NOTES:

1) For full thickness flat tensile test specimens with a width of 25 [mm] and a gauge length of 200 [mm] the elongation [%] is to comply with the following minimum values:

Grade	Thickness [mm]							
	≤ 5	> 5 ≤ 10	> 10 ≤ 15	> 15 ≤ 20	> 20 ≤ 25	> 25 ≤ 30	> 30 ≤ 40	> 40 ≤ 50
AH32, DH32, EH32 & FH32	14	16	17	18	19	20	21	22
AH36, DH36, EH36 & FH36	13	15	16	17	18	19	20	21
AH40, DH40, EH40 & FH40	12	14	15	16	17	18	19	20

2) See 2.4.9.

3) For Grades A32 and A36 steels a relaxation in the number of impact tests for acceptance purposes may be permitted by special agreement with IRS provided that satisfactory results are obtained from occasional check tests.

Table 3.4.2: Conditions of supply, grade and mechanical properties for EH47 steel plates

Supply Condition	Grade	Mechanical Properties			Impact Test			
		Yield Strength [N/mm^2]min	Tensile Strength [N/mm^2]	Elongation (%) min.	Test Temp. (^{o}C)	Average Impact Energy [J] min.		
						50<t<70	70<t<85	85<t<100
TMCP	EH 47	460	570/720	17	-40^{o}C	53	64	75

Note : t: Thickness [mm]

Section 4

High Strength Quenched and Tempered Steels for Welded Structures

4.1 General

4.1.1 These requirements apply to weldable high strength and tempered steel plates and wide flats up to 70 [mm] thickness. The application of these requirements for products with thicknesses above 70 [mm] and for product forms other than plates and wide flats such as sections and tubulars, are to be specially agreed.

4.1.2 Steel differing from the requirements in this section in respect of chemical composition, deoxidation practice, heat treatment or mechanical properties may be accepted, subject to special approval by IRS.

4.1.3 The steel covered by the scope of these requirements are divided into six yield strength levels of 420, 460, 500, 550, 620 and 690 [N/mm^2]. For each yield strength level four grades AH, DH, EH and FH are specified, based on the impact test temperature.

4.1.4 Special consideration may be given to the supply of those steels in thickness upto 50 [mm] in the TMCP condition subject to approval of IRS.

4.2 Approval

4.2.1 The steels must be approved by IRS and for this purpose the steel maker is to submit a specification containing such details as chemical composition, manufacturing process, mechanical properties, delivery condition, recommendation for welding, cold and hot forming and heat treatment. In addition, IRS may require initial approval tests to be performed. Weldability of each grade of steel is to be demonstrated by the steel maker during the initial approval procedure to the satisfaction of IRS.

4.3 Deoxidation and chemical composition

4.3.1 The steel shall be fully killed and fine grain treated.

4.3.2 The chemical composition is to be determined by the steel maker, in an adequately equipped competently staffed laboratory, from each cast or ladle and is to comply with the requirements of the approved specifications and limits given in Table 4.3.1.

4.3.3 The cold cracking susceptibility P_{cm} for evaluating weldability should be calculated from the ladle analysis in accordance with the following formula.

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

The maximum P_{cm} to be achieved is to be agreed with IRS and included in the approved specification.

4.4 Heat treatment

4.4.1 All materials are to be supplied in the quenched and tempered condition. This requirement excludes precipitation hardening steels.

Table 4.3.1 : Chemical composition

Yield strength level [N/mm^2]	Grade	Maximum content of elements per cent[1)]					
		C	Si	Mn	P	S	N
420 to 690	AH	0.21	0.55	1.70	0.035	0.035	0.020
420 to 690	DH	0.20	0.55	1.70	0.030	0.030	0.020
420 to 690	EH	0.20	0.55	1.70	0.030	0.030	0.020
420 to 690	FH	0.18	0.55	1.60	0.025	0.025	0.020

1) Elements used for alloying and fine grain treatment are to be as detailed in the approved specification.

4.5 Mechanical tests

4.5.1 Sizes and orientation of test specimens are to be in accordance with the requirements of Sec. 1.

4.5.2 One tensile and one set of three Charpy V-notch impact tests are to be made on each piece as heat treated. For continuous heat treated plates special consideration may be given regarding the number and location of test specimens required.

4.5.3 The tensile test specimens are to be taken as given in 1.6.3.1 and 1.6.3.2. The results of all tensile tests are to comply with the appropriate requirements given in Table 4.5.1 and Table 4.5.2. In the case of other product forms (See 1.6.3.3), where longitudinal tests have been agreed, the elongation values are to be 2 percent units above those given in Table 4.5.1 and Table 4.5.2.

4.5.4 Unless otherwise accepted by IRS, the V-notch impact test specimens for plates and wide flats over 600 [mm] are to be taken with their axes transverse to the main rolling direction and the results should comply with the appropriate requirements of Table 4.5.1 and Table 4.5.2. For other product forms the impact tests are to be in the longitudinal direction, the results of tests are to comply with appropriate requirements of Table 4.5.1 and Table 4.5.2. Normally sub-surface test specimens will be taken, however, for material with a thickness in excess of 40 [mm], impact tests should be taken at the quarter thickness (t/4) location.

4.5.5 If required by IRS, through thickness tensile tests are to be performed in accordance with the requirements of Sec. 8.

Table 4.5.1 : Mechanical properties requirements, 70 [mm] maximum thickness

Grade of steel	Yield stress [N/mm^2] min. (See Note 1)	Tensile strength [N/mm^2]	Elongation per cent min. (Lo = 5.65√So) (See Note 2)	Impact Tests (See Note 3)	
				Test temp.°C	Average energy (J) min.
AH 420	420	530 - 680	18	0	42(L) 28(T)
DH 420	420	530 - 680	18	-20	42(L) 28(T)
EH 420	420	530 - 680	18	-40	42(L) 28(T)
FH 420	420	530 - 680	18	-60	42(L) 28(T)
AH 460	460	570 - 720	17	0	46(L) 31(T)
DH 460	460	570 - 720	17	-20	46(L) 31(T)
EH 460	460	570 - 720	17	-40	46(L) 31(T)
FH 460	460	570 - 720	17	-60	46(L) 31(T)
AH 500	500	610 - 770	16	0	50(L) 33(T)
DH 500	500	610 - 770	16	-20	50(L) 33(T)
EH 500	500	610 - 770	16	-40	50(L) 33(T)
FH 500	500	610 - 770	16	-60	50(L) 33(T)
AH 550	550	670 - 830	16	0	55(L) 37(T)
DH 550	550	670 - 830	16	-20	55(L) 37(T)
EH 550	550	670 - 830	16	-40	55(L) 37(T)
FH 550	550	670 - 830	16	-60	55(L) 37(T)
AH 620	620	720 - 890	15	0	62(L) 41(T)
DH 620	620	720 - 890	15	-20	62(L) 41(T)
EH 620	620	720 - 890	15	-40	62(L) 41(T)
FH 620	620	720 - 890	15	-60	62(L) 41(T)
AH 690	690	770 - 940	14	0	69(L) 46(T)
DH 690	690	770 - 940	14	-20	69(L) 46(T)
EH 690	690	770 - 940	14	-40	69(L) 46(T)
FH 690	690	770 - 940	14	-60	69(L) 46(T)

L = Longitudinal;

T = transverse.

Note 1 : Where the yield stress is not marked in the tensile test, the 0.2% proof stress is applicable.

Note 2 : For full thickness flat test specimens with a width of 25 [mm] and a gauge length of 200 [mm] the elongation is to comply with the minimum values shown in Table 4.5.2

Note 3 : For A grade steels, a reduction in the number of impact tests required for acceptance purpose may be permitted by special agreement with IRS provided that satisfactory results are obtained from occasional check tests.

Table 4.5.2 : Elongation minimum values for a width of 25 [mm] and a 200 [mm] gauge length

Strength Grade	Thickness [mm]						
	≤ 10	> 10 ≤ 15	> 15 ≤ 20	> 20 ≤ 25	> 25 ≤ 40	> 40 ≤ 50	> 50 ≤ 70
420	11	13	14	15	16	17	18
460	11	12	13	14	15	16	17
500	10	11	12	13	14	15	16
550	10	11	12	13	14	15	16
620	9	11	12	12	13	14	15
690	9	10	11	11	12	13	14

Section 5

Steel for Low Temperature Service

5.1 General

5.1.1 This section gives specific requirements for carbon-manganese and nickel alloy steels with toughness properties at low temperatures and intended for use in the construction of cargo tanks and process pressure vessels for liquefied gases.

5.1.2 The requirements of this section are also applicable for other types of pressure vessels where the use of steels with guaranteed impact properties at low temperature is required.

5.1.3 Provision is made for plates and sections up to 40 [mm] thick.

5.1.4 Steel differing in chemical composition, condition of supply or mechanical properties may be accepted, subject to special agreement by IRS.

5.2 Deoxidation and chemical composition

5.2.1 All steels are to be in the fully killed and fine grain refined condition.

5.2.2 The chemical composition of carbon-manganese steels are to comply with the appropriate requirements of grades AH, DH, EH and FH strength levels 32, 36 and 40 (See Table 3.2.1). However these grades are to be designated as L T -AH, L T -DH, L T -EH and L T -FH respectively for the uses defined in 5.1.1.

5.2.3 The chemical compositions of nickel alloy steels are to comply with the appropriate requirements of Table 5.2.1.

Table 5.2.1 : Chemical composition of nickel alloy steels				
Elements	**1.5 Ni**	**3.5 Ni**	**5 Ni**	**9 Ni**
C max.	0.18	0.15	0.12	0.10
Si	0.10 - 0.35	0.10 - 0.35	0.10 - 0.35	0.10 - 0.35
Mn	0.30 - 1.50	0.30 - 0.90	0.30 - 0.90	0.30 - 0.90
Ni	1.30 - 1.70	3.20 - 3.80	4.70 - 5.30	8.50 - 10.0
P max.	0.025	0.025	0.025	0.025
S max.	0.020	0.020	0.020	0.020
Al min. (acid soluble)[1)]	0.015	0.015	0.015	0.015
Residual elements				
Cr max.	0.25	0.25	0.25	0.25
Cu max.	0.35	0.35	0.35	0.35
Mo max.	0.08	0.08	0.08	0.08
Total of residual elements max.	0.60	0.60	0.60	0.60
1) The total aluminium content may be determined by other methods instead of the acid soluble method. In such cases the total aluminium content is to be not less than 0.020 percent.				

5.3 Heat treatment

5.3.1 All materials are to be supplied in a condition complying with Table 5.3.1.

Table 5.3.1 : Conditions of supply		
Grade	**Plates**	**Sections and Bars**
LT-AH LT-DH	N, TMCP N, TMCP	Any Any
LT-EH LT-EH	N^2, TMCP, QT N^2, TMCP, QT	N, TMCP N, TMCP
1.5 Ni 3.5 Ni 5 Ni	N^2, QT, normalized and tempered N^2, QT, normalized and tempered N^2, QT, normalized and tempered	
9 Ni	QT, Double normalized and tempered	

1	N = Normalized TMCP = Thermo-mechanically controlled process QT = Quenched and tempered
2	The term "Normalized" does not include normalized rolling.

5.4 Mechanical tests

5.4.1 Test pieces for tensile testing of plates are to be cut with their principal axes transverse to the final direction of rolling.

5.4.2 For each batch of plate presented, one tensile test is to be made from one end of each piece unless the mass and length of the piece exceeds 5 tonnes and 15 m in which case test pieces are to be taken from both ends of each piece.

5.4.3 Sections and bars are to be presented for acceptance test in batches containing not more than 50 lengths, as supplied. The material in each batch is to be of the same section size, from the same cast and in the same condition of supply. One tensile test specimen is to be taken from material representative of each batch, except that additional tests are to be taken when the mass of a batch exceeds 10 tonnes.

5.4.4 One set of three Charpy V-notch impact test specimens are to be taken for each tensile test specimen required. For plates, these are to be cut with their principal axis perpendicular to the final direction of rolling and for sections. these are to be taken longitudinally.

5.4.5 The results of all tensile tests are to comply with appropriate requirements given in Table 5.4.1. The ratio between the yield stress and the tensile strength is not to exceed 0.9 for normalized and TMCP steels and 0.94 for Q & T steels.

5.4.6 The average energy value from each set of three impact tests are to comply with appropriate requirements given in Table 5.4.1.

5.4.7 When standard subsidiary impact specimens are necessary (See Sec. 2).

5.4.8 When steel with improved through thickness properties is required or specified in the order, the materials are to be tested as detailed in Sec. 8.

Table 5.4.1 : Mechanical properties for acceptance purposes

Grade of Steel		Yield stress [N/mm^2] min.	Tensile strength [N/mm^2]	Elongation on $5.65\sqrt{S_o}$ % min.	Charpy V-notch impact test	
					Test temp.°C	Impact Energy min.
LT-AH	32	315	440 - 590	22	0	Plates transverse tests Average energy 27 J Sections and bars longitudinal tests Average energy 41 J
	36	355	490 - 620	21		
	40	390	510 - 650	20		
LT-DH	32	315	440 - 590	22	-20	
	36	355	490 - 620	21		
	40	390	510 - 650	20		
LT-EH	32	315	440 - 590	22	-40	
	36	355	490 - 620	21		
	40	390	510 - 650	20		
LT-FH	32	315	440 - 590	22	-60	
	36	355	490 - 620	21		
	40	390	510 - 650	20		
1.5 Ni		275	490 - 640	22	-80	
3.5 Ni		285	450 - 610	21	-95	
5 Ni		390	540 - 740	21	-110	
9 Ni		490	640 - 790	18	-196	

Notes:

1 These requirements are applicable to products not exceeding 40 [mm] in thickness. The requirements for thicker products are subject to agreement.

2 The minimum design temperatures at which plates of different thicknesses in the above grades may be used are given in Pt.3, Ch.2, Table 2.4.1 and Pt.5, Ch.4, Table 6.1.2 and Table 6.1.3. Consideration will be given to the use of thicknesses greater than those in the table or to the use of temperatures below - 165°C

Section 6

Steels for Boilers and Pressure Vessels

6.1 General

6.1.1 The following requirements are for carbon, carbon-manganese and alloy steels intended for use in the construction of boilers and pressure vessels. In addition to specifying mechanical properties at ambient temperature for the purpose of acceptance testing, these requirements also give details of appropriate mechanical properties at elevated temperatures which may be used for design purposes.

6.1.2 Where it is proposed to use a carbon or carbon-manganese steel with a specified minimum tensile strength intermediate to the following specified properties, corresponding minimum values for yield and elongation and mechanical properties at elevated temperatures may be obtained by interpolation.

6.1.3 Carbon and carbon-manganese steels with a specified minimum tensile strength of greater than 490 [N/mm^2] but not exceeding 520 [N/mm^2] may be accepted provided that details of proposed specifications are submitted for approval.

6.1.4 Where it is proposed to use alloy steels other than those specified herein, details of the specifications are to be submitted for approval. In such cases the specified minimum tensile strength is not to exceed 600 [N/mm^2].

6.1.5 Materials intended for use in the construction of the cargo tanks and process pressure vessels, storage tanks for liquefied gases and for other low temperature applications are to comply with the requirements of Sec. 5.

6.2 Deoxidation and chemical composition

6.2.1 The method of deoxidation and the chemical analysis of ladle samples is to comply with the requirements of Table 6.2.1.

Table 6.2.1 : Deoxidation and chemical composition

Grade of steel	Deoxidation	Chemical composition per cent						
C and C-Mn steel		C max.	Si	Mn	P max.	S max.	Al	Residual elements
360 AR	Any method except rimmed steel	0.18	0.50 max.	0.40-1.30	0.040	0.04	-	Cr 0.25 max. Cu 0.30 max. Mo 0.10 max. Ni 0.30 max. Total 0.70 max.
410 AR		0.21	0.50 max.	0.40-1.30	0.040	0.040	-	
460 AR		0.23	0.50 max.	0.80-1.50	0.040	0.040	-	
360	Any method except rimmed steel	0.17	0.35 max.	0.40-1.20	0.035	0.035	-	
410		0.20	0.35 max.	0.50-1.30	0.035	0.035	-	
460		0.20[1]	0.40 max.	0.80-1.40	0.035	0.035	-	
490	Killed	0.20[1]	0.10-0.50	0.90-1.60	0.035	0.035		
360 FG	Killed fine grained	0.17	0.35 max.	0.40-1.20	0.035	0.035	See note 2	
410 FG		0.20	0.35 max.	0.50-1.30	0.035	0.035	See note 2	
460 FG		0.20[1]	0.40 max.	0.80-1.50	0.035	0.035	See note 2	
490 FG		0.20[1]	0.10-0.50	0.90-1.60	0.035	0.035	See note 2	

Alloy steels	Deoxi-dation	C	Si	Mn	P max.	S max.	Al	Cr	Mo	Residual elements
1 Cr 1/2 Mo 470	Killed	0.10-0.18	0.15-0.35	0.4-0.8	0.035	0.035	See note 3	0.70-1.30	0.40-0.60	Cu 0.30 max. Ni 0.30 max.
2 1/4 Cr 1 Mo 480		0.08-0.18	0.15-0.50	0.4-0.8	0.035	0.035	See note 3	2.00-2.50	0.90-1.10	

Notes:

1 For thickness greater than 30 [mm], carbon 0.22 percent max.

2 Aluminium (acid soluble) 0.015 per cent min, or Aluminium (total) 0.018 percent min. Niobium, Vanadium or other suitable grain refining elements may be used either in place of or in addition to aluminium.

3 Aluminium (acid soluble or total) 0.020 percent max.

6.3 Heat treatment, condition of supply

6.3.1 All materials are to be supplied in a condition complying with the requirements of Table 6.3.1.

However, when agreed, material intended for hot forming may be supplied in the as rolled condition.

Table 6.3.1 : Heat treatment	
Grade of steel	**Condition of supply**
Carbon and carbon- manganese 360 AR to 460 AR	As rolled, maximum thickness or diameter is 40 [mm]
Carbon and carbon- manganese 360 to 490	Normalized or controlled rolled
Carbon and carbon- manganese 360 FG to 490 FG	Normalized or controlled rolled
1Cr 1/2 Mo 470	Normalized and tempered
2 1/4 Cr 1 Mo 480	Normalized and tempered

6.4 Mechanical tests

6.4.1 For plates a tensile test specimen is to be taken from one end of each piece when the weight does not exceed 5 tonnes and the length does not exceed 15 [m]. When either of these limits is exceeded, tensile test specimens are to be taken from both ends of each piece. A piece is to be regarded as the rolled product from a single slab or a single ingot, if this is rolled directly into plates.

6.4.2 For strips, tensile test specimens are to be taken from both ends of each coil.

6.4.3 Sections and bars are to be presented for acceptance tests in batches containing not more than 50 lengths, as supplied. The material in each batch is to be of the same section size, from the same cast and in the same condition of supply. One tensile test specimen is to be taken from material representative of each batch, except that additional tests are to be taken when the weight of a batch exceeds 10 tonnes.

6.4.4 Where plates are required for hot forming and it has been agreed that the heat treatment will be carried out by the fabricator, the tests at the steel works are to be made on material which has been cut from the plates and given a normalizing or normalizing and tempering heat treatment in a manner simulating the treatment which will be applied to the plates.

6.4.5 If required by the Surveyors or by the fabricator test material may be given a simulated stress relieving heat treatment prior to the preparation of the test specimens. This has to be stated on the order together with agreed details of the simulated heat treatment and the mechanical properties which can be accepted.

6.4.6 The results of the tensile tests are to comply with the appropriate requirements given in Table 6.4.1, Table 6.4.2 and Table 6.4.3.

Table 6.4.1 : Mechanical properties for acceptance purposes : carbon and carbon-manganese steels - as rolled				
Grade of steel	**Thick-ness [mm]**	**Yield stress [N/mm^2] min.**	**Tensile strength [N/mm^2]**	**Elonga-tion on 5.65√So % min.**
360 AR	≤ 40	190	360-480	24
410 AR	≤ 40	215	410-530	22
460 AR	≤ 40	240	460-580	21

Table 6.4.2 : Mechanical properties for acceptance purposes : carbon and carbon-manganese steels-normalized or controlled rolled

Grade of steel	Thickness [mm] (see Note)	Yield stress [N/mm^2] min.	Tensile strength [N/mm^2]	Elongation on 5.65√So % min.
360	> 3 ≤ 16 > 16 ≤ 40 > 40 ≤ 63	205 195 185	360 - 480	26 26 25
410	> 3 ≤ 16 > 16 ≤ 40 > 40 ≤ 63	235 225 215	410 - 530	24 24 23
460	> 3 ≤ 16 > 16 ≤ 40 > 40 ≤ 63	285 255 245	460 - 580	22 22 21
490	> 3 ≤ 16 > 16 ≤ 40 > 40 ≤ 63	305 275 265	490 - 610	21 21 20
360 FG	> 3 ≤ 16 > 16 ≤ 40 > 40 ≤ 63	235 215 195	360 - 480	26 26 25
410 FG	> 3 ≤ 16 > 16 ≤ 40 > 40 ≤ 63	265 245 235	410 - 530	24 24 23
460 FG	> 3 ≤ 16 > 16 ≤ 40 > 40 ≤ 63	295 285 275	460 - 580	22 22 21
490 FG	> 3 ≤ 16 > 16 ≤ 40 > 40 ≤ 63	315 315 305	490 - 610	21 21 21

Note:

For thicknesses greater than 63 [mm], the minimum values for yield stress may be reduced by 1 per cent for each 5 [mm] increment in thickness over 63 [mm]. The minimum elongation values may also be reduced one unit, e.g. 20 percent reduced to 19 percent for all thicknesses over 63 [mm]. For thicknesses over 100 [mm], the above values are to be agreed.

Table 6.4.3 : Mechanical properties for acceptance purposes : alloy steels-normalized and tempered

Grade of steel	Thickness [mm] (see Note)	Yield stress [N/mm^2] min.	Tensile strength [N/mm^2]	Elongation on 5.65√So % min.
1 CR 1/2 Mo 470	> 3 ≤ 16 > 16 ≤ 40 > 40 ≤ 63	305 305 305	470 - 620	20 20 19
2 1/4 Cr 1 Mo 480	> 3 ≤ 16 > 16 ≤ 40 > 40 ≤ 63	275 265 265	480 - 630	18 18 17

Table 6.4.3 (Contd.)

Note:

For thicknesses greater than 63 [mm], the minimum values for yield stress may be reduced by 1 per cent for each 5 [mm] increment in thickness over 63 [mm]. The minimum elongation values may also be reduced one unit, e.g. 20 percent reduced to 19 percent for all thicknesses over 63 [mm]. For thicknesses over 100 [mm], the above values are to be agreed.

6.5 Mechanical properties for design purposes at elevated temperatures

6.5.1 Nominal values for the minimum lower yield or 0.2 per cent proof stress at temperatures of 50°C and higher are given in the following tables :

Table 6.5.1 Carbon and carbon manganese steels - As rolled (applicable only when the design temperature does not exceed 350°C).

Table 6.5.2 Carbon and carbon-manganese steels normalized or controlled rolled.

Table 6.5.3 Alloy steels. Normalized and tempered.

6.5.2 These values are intended for design purposes only and verification is not required except for materials complying with National or proprietary specifications where the elevated temperature properties used for design purposes are higher than those given in Table 6.5.1 to Table 6.5.3. The extent of testing in such cases would have to be specially agreed by IRS.

6.5.3 Values for the estimated average stress to rupture in 100,000 hours are given in Table 6.5.4 and may be used for design purposes.

Table 6.5.1 : Mechanical properties for design purposes - Carbon and carbon - manganese steels - as rolled

Grade of steel	Thickness [mm]	Design temperature°C (See Note)						
		50	**10**	**150**	**200**	**250**	**300**	**350**
		Nominal minimum lower yield or 0.2 percent proof stress [N/mm^2]						
360 AR	≤ 40	154	153	152	145	128	108	102
410 AR		186	183	181	174	155	134	127
460 AR		218	213	210	203	182	161	153
Note : Maximum permissible design temperature is 350°C								

Table 6.5.2 : Mechanical properties for design purposes - carbon and carbon - manganese steels - normalized or controlled rolled

Grade of steel	Thickness [mm] (see Note)	Design temperature °C								
		50	**100**	**150**	**200**	**250**	**300**	**350**	**400**	**450**
		Nominal minimum lower yield or 0.2 percent proof stress [N/mm^2]								
360	> 3 ≤ 16	183	175	172	168	150	128	117	115	113
	> 16 ≤ 40	173	171	169	162	144	124	117	115	113
	> 40 ≤ 63	166	162	158	152	141	124	117	115	113
410	> 3 ≤ 16	220	211	208	201	180	150	142	138	136
	> 16 ≤ 40	204	201	198	191	171	150	142	138	136
	> 40 ≤ 63	196	192	188	181	168	150	142	138	136
460	> 3 ≤ 16	260	248	243	235	210	176	168	162	158
	> 16 ≤ 40	235	230	227	220	198	176	168	162	158
	> 40 ≤ 63	227	222	218	210	194	176	168	162	158
490	> 3 ≤ 16	280	270	264	255	228	192	183	177	172
	> 16 ≤ 40	255	248	245	237	214	192	183	177	172
	> 40 ≤ 63	245	240	236	227	210	192	183	177	172
360 FG	> 3 ≤ 16	214	204	185	165	145	127	116	110	106
	> 16 ≤ 40	200	196	183	164	145	127	116	110	106
	> 40 ≤ 63	183	179	172	159	145	127	116	110	106
410 FG	> 3 ≤ 16	248	235	216	194	171	152	141	134	130
	> 16 ≤ 40	235	228	213	192	171	152	141	134	130
	> 40 ≤ 63	222	215	204	188	171	152	141	134	130
460 FG	> 3 ≤ 16	276	262	247	223	198	177	167	158	153
	> 16 ≤ 40	217	260	242	220	198	177	167	158	153
	> 40 ≤ 63	262	251	236	217	198	177	167	158	153
490 FG	> 3 ≤ 16	297	284	265	240	213	192	182	173	168
	> 16 ≤ 40	293	279	260	237	213	192	182	173	168
	> 40 ≤ 63	286	272	256	234	213	192	182	173	168

Note : For thicknesses greater than 63 [mm], the values for lower yield or 0.2 percent stress are to be reduced by 1 percent for each 5 [mm] increment in thickness upto 100 [mm]. For thicknesses over 100 [mm], the values are to be agreed and verified by test.

Table 6.5.3 : Mechanical properties for design purposes : alloy steels-normalized tempered

Grade of steel	Thickness [mm] (see Note)	Design temperature °C									
		50	100	200	300	350	400	450	500	550	600
		Nominal minimum lower yield or 0.2 percent proof stress [N/mm^2]									
1 Cr 1/2 Mo 470	$3 \leq 63$	284	270	248	216	203	199	194	188	181	174
2 1/4 Cr 1 Mo 480	$3 \leq 63$	255	249	233	219	212	207	194	180	160	137

Note : For thicknesses greater than 63 [mm], the values for lower yield or 0.2 percent stress are to be reduced by 1 percent for each 5 [mm] increment in thickness upto 100 [mm]. For thicknesses over 100 [mm], the values are to be agreed and verified by test.

Table 6.5.4 : Mechanical properties for design purposes : estimated average values for stress to rupture in 100,000 hours [N/mm^2]

Temp. °C	Grades of steel				
	Carbon and carbon-manganese			Alloy Steels	
	360 FG 410 FG 460 FG	360 410 460	490 490 FG 510 FG	1 Cr 1/2 Mo 470	2 1/4 Cr 1 Mo 480
380	171	219	227	-	-
390	155	196	203	-	-
400	141	173	179	-	-
410	127	151	157	-	-
420	114	129	136	-	-
430	102	109	117	-	-
440	90	92	100	-	-
450	78	78	85	-	221
460	67	67	73	-	204
470	57	57	63	-	186
480	47	48	55	210	170
490	36	-	47	177	153
500	-	-	-	146	137
510	-	-	-	121	122
520	-	-	-	99	107
530	-	-	-	81	93
540	-	-	-	67	79
550	-	-	-	54	69
560	-	-	-	43	59
570	-	-	-	35	51
580	-	-	-	-	44

Section 7

Steels for Machinery Structures

7.1 General

7.1.1 Steel plates, strips, sections or bars intended for use in the construction of welded machinery structures are to comply with one of the following alternatives:

a) Any grade of normal strength structural steel or high strength structural steel as detailed in Sec. 2 and 3.

b) Any grade of carbon or carbon-manganese steel as detailed in Sec. 6 except that for this application batch testing is acceptable and the same is to be carried out in accordance with the requirements of Sec. 2.

Section 8

Plates with Specified minimum through Thickness Properties ('Z' quality)

8.1 General

8.1.1 Following requirements are for special quality plate material with improved ductility in the through thickness or "Z direction.

8.1.2 The use of this material known as 'Z' quality steel, is recommended when plate material, intended for welded construction, will be subject to significant strain in a direction perpendicular to the rolled surfaces. These strains are usually associated with thermal contraction and restraint during welding, particularly for full penetration "T"- butt welds but may also be associated with loads applied in service or during construction. Where these strains are of sufficient magnitude, lamellar tearing may occur. Two 'Z' quality steels are specified; Z25 for normal ship applications and 'Z35' for more severe applications.

Through thickness properties are characterized by specified values for reduction of area in a through thickness tensile test.

8.1.3 This special quality material is to comply with the requirements of Sec. 2, 3, 4, 5, 6 and 7 as appropriate and the following additional requirements.

8.2 Manufacture

8.2.1 All plates are to be manufactured at works which have been approved by IRS for this quality of material.

8.2.2 The sulphur content is not to exceed 0.008 per cent, as determined by ladle analysis. It is recommended that the steel should be efficiently vacuum de-gassed.

8.3 Test material

8.3.1 Unless otherwise agreed, through thickness tensile tests are only required for plate materials where the thickness exceeds 15 [mm]. A test sample large enough to provide six test specimens are to be cut from the centre of one end of each rolled piece representing the batch. (See Fig.8.3.1). Where appropriate the end selected should be representative of the top end of an ingot or the start of a concast strand. Generally three through thickness tensile test specimens are to be prepared while the rest of the sample remains for possible retests.

8.3.2 The batch size is to be determined depending on the product and sulphur content as given in Table 8.3.2.

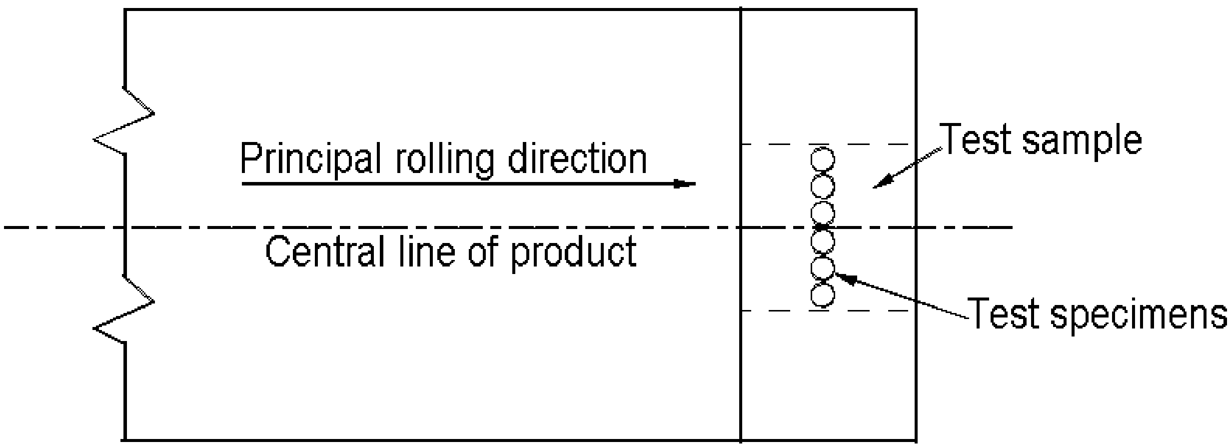


Fig.8.3.1 : Plate and wide flat sampling position

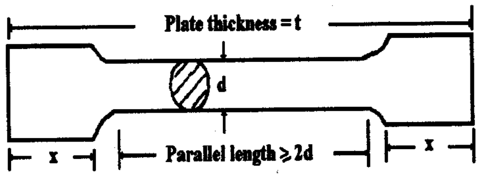
Table 8.3.2 : Batch size dependent on product and sulphur content		
Product	**S > 0.005%**	**S ≤ 0.005%**
Plates	Each piece (parent plate)	Maximum 50t of products of the same cast, thickness and heat treatment
Wide flats of nominal thickness ≤ 25 mm	Maximum 10t of products of the same cast, thickness and heat treatment	Maximum 50t of products of the same cast, thickness and heat treatment
Wide flats of nominal thickness > 25 mm	Maximum 20t of products of the same cast, thickness and heat treatment	Maximum 50t of products of the same cast, thickness and heat treatment

8.4 Dimensions of through thickness tensile test specimens

8.4.1 At the option of the steel maker test specimens (Fig.8.4.1a) or test specimens with welded extensions (Fig.8.4.1b) may be used. For both types of test specimens, the diameter of the parallel portion is not to be less than 6 [mm] when plate thickness is less than or equal to 25 [mm] and 10 [mm] when the plate thickness is greater than 25 [mm].

Alternatively, round test specimens, including those with welded extensions, may be prepared in accordance with a recognized standard.

8.4.2 The tolerances on specimen dimensions are to be in accordance with ISO 6892-98 or other recognised standards as appropriate.

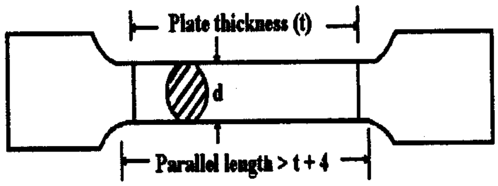


t = thickness of plate [mm]
d = 6 mm; when 15 mm ≤ t ≤ 25 [mm]
d = 10 mm min. when t > 25 [mm]
x = 5 mm max. when d = 6 [mm]
x = 8 mm max. when d = 10 [mm]

Fig 8.4.1 (a) : Plain test specimen

8.5 Mechanical tests

8.5.1 The acceptable minimum average value for the reduction of area of the three tensile test specimens taken in the through thickness direction are given in Table 8.5.1. Only one individual value may be below the minimum average, but not less than the minimum individual value for the appropriate grade.



t = Thickness of plate [mm]
d = 6 mm; when 15 mm ≤ t ≤ 25 [mm]
d = 10 mm when t 25 [mm]

Fig 8.4.1 (b) : Test specimen with welded extension

Table 8.5.1 : Reduction of area acceptance values

Grade	Z25	Z35
Minimum average	25%	35%
Minimum individual	15%	25%

8.5.2 A value less than minimum individual value will require rejection of the piece. However, in case of batch testing each remaining piece in the batch may be individually tested.

8.5.3 Depending on the test results, retest may be permitted in the cases shown in Fig.8.5.3. In these instances, three more tensile tests are to be taken from the remaining test sample. The average of all 6 tensile tests is to be greater than the required minimum average with not more than two results below the minimum average.

In case of failure after retest, either the batch represented by the piece is rejected or each piece within batch may be retested.

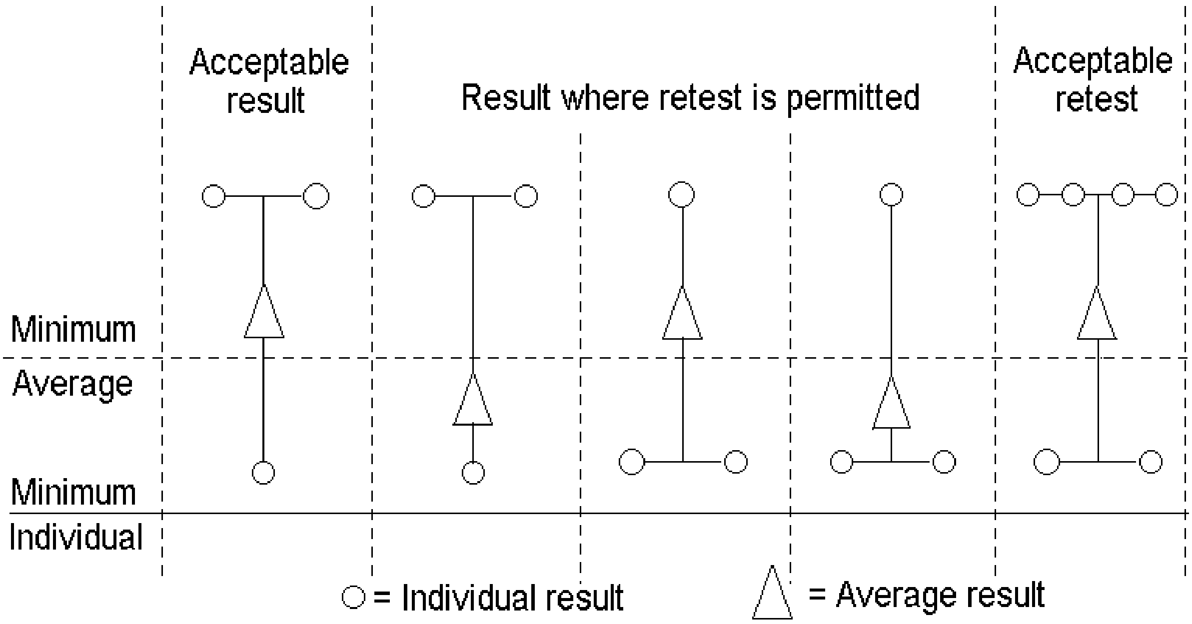


Fig.8.5.3 : Diagram showing acceptance / rejection and retest criteria

8.6 Non-destructive examination

8.6.1 All special 'Z' quality plates are to be ultrasonically tested in the final supply condition, with a probe of frequency 4 MHz. The ultrasonic testing is to be carried out in accordance with either EN 10160-1989 Level S2/E3 or ASTM A578 Level C.

Section 9

Austenitic and Duplex Stainless Steels

9.1 Scope

9.1.1 This section gives the requirements for rolled products in austenitic and duplex (austenite plus ferrite) stainless steels intended for use in the construction of cargo tanks, storage tanks and process pressure vessels for chemicals and liquefied gases.

9.1.2 Austenitic stainless steels are suitable for applications where the lowest design temperature is not lower than –165°C.

9.1.3 Austenitic stainless steels are also suitable for service at elevated temperatures and for such applications the proposed specification should contain, in addition to the requirements of 9.1.6, minimum values for 0.2 and 1.0 per cent proof stresses at the design temperature.

9.1.4 Duplex stainless steels are suitable for applications where the lowest design temperature is above 0°C. Any requirement to use duplex stainless steels below 0°C will be subject to special consideration.

9.1.5 Duplex stainless steels are also suitable for service at temperatures upto 300°C and for such applications the proposed specification should include, in addition to the requirements of 9.1.6, a minimum value for 0.2 per cent proof stress at the design temperature.

9.1.6 A specification giving details of the chemical composition, heat treatment and mechanical properties, including for the austenitic grades, both the 0.2 and 1.0 percent proof stresses, is to be submitted for consideration and approval.

9.2 Chemical composition

9.2.1 The chemical composition of ladle samples is to comply with the requirements given in Table 9.2.1.

9.3 Heat treatment

9.3.1 All materials are to be supplied in the solution treated condition.

Table 9.2.1 : Chemical composition

Type and grade of steel	Chemical composition % (see Note)									
	C max	Si max	Mn max	P max	S max	Cr	Ni	Mo	N	Other
Austenitic										
304L	0.03	}	}	}	}	17.0-20.0	8.0-13.0	-	0.10	-
304LN	“	}	}	}	}	17.0-20.0	3.0-12.0	-	0.10-0.22	-
316L	“	}	}	}	}	16.0-18.5	10.0-15.0	2.0-3.0	0.10	-
316LN	“	1.0	2.0	0.045	0.03	16.0-18.5	10.0-14.5	2.0-3.0	0.10-0.22	-
317L	“	}	}	}	}	18.0-20.0	11.0-15.0	3.0-4.0	0.10	-
317LN	“	}	}	}	}	18.0-20.0	12.5-15.0	3.0-4.0	0.10-0.22	-
321	0.06	}	}	}	}	17.0-19.0	9.0-12.0	-	0.10	5xC≤Ti≤0.7
347	0.06	}	}	}	}	17.0-19.0	9.0-13.0	-	0.10	10xC≤Nb≤1.0
Duplex										
UNS S31803	0.03	1.0	2.0	0.03	0.02	21.0-23.0	4.5-6.5	2.5-3.5	0.08-0.20	-
UNS S32750	0.03	0.80	1.2	0.035	0.02	24.0-26.0	6.0-8.0	3.0-5.0	0.24-0.32	Cu 0.50 max.

9.4 Mechanical tests

9.4.1 Tensile test specimens are to be taken in accordance with the appropriate requirements of 5.4 and 6.4.1.

9.4.2 For the duplex grades, one set of three Charpy V-notch impact test specimens machined in the longitudinal direction from each tensile test piece is to be tested at –20°C. The average energy value of the three specimens is to be not less than 41 Joules.

For austenitic grades of steel, impact tests are only required for design temp. below –105°C. In such cases, impact tests carried out at a temperature of –196°C on a set of three charpy V-notch specimens are to comply with the following:

a) Plates : Transverse test pieces; minimum average energy value 27 Joules.
b) Strips, sections and bars : Longitudinal test pieces, minimum average energy value 41 Joules.

9.4.3 Where standard subsidiary Charpy V-notch test specimens are necessary, see Chapter 2, Sec.3.1.2.

9.4.4 The results of all tensile tests are to comply with the requirements of Table 9.4.1 or the approved specification.

9.5 Through thickness tests

9.5.1 Where material will be strained in a through thickness direction during welding or in service, through thickness tests are required on plates over 10 [mm] thick in all the grades of steels listed in Table 9.2.1, apart from Grades 304L, 304LN, 321 and 347.

9.5.2 Testing is to conform with the requirements of Section 8, with the exception given in 9.5.3.

9.5.3 When the reduction in area is less than 35 per cent, metallographic or other evidence is required to show that no significant amount of any detrimental phase, such as sigma, is present.

Table 9.4.1 : Mechanical properties for acceptance purposes

Type and grade of steel	0.2% proof stress [N/mm^2] minimum	1% proof stress [N/mm^2] minimum	Tensile strength [N.mm^2] minimum	Elongation on 5.65 $\sqrt{S_o}$ % minimum
Austenitic				
304L	170	210	485	40
304LN	205	245	515	40
316L	170	210	485	40
316LN	205	245	515	40
317L	205	245	515	40
317LN	240	280	550	40
321	205	245	515	40
347	205	245	515	40
Duplex				
UNS S 31803	450	-	620	25
UNS S 32750	550	-	795	15

9.6 Intergranular corrosion tests

9.6.1 For certain specific applications such as storage tanks for chemicals, it may be necessary to demonstrate that the material used is not susceptible to intergranular corrosion resulting from grain boundary precipitation of chromium-rich carbides.

9.6.2 When required, one test of this type is to be carried out for each tensile test. The testing is to be carried out in accordance with ASTM A262, practice E, copper-copper sulphate-sulphuric acid or another recognized standard. The bent specimen is to be free from cracks indicating the presence of intergranular attack. The material for the test is to be taken adjacent to that for the tensile test.

9.7 Dimensional tolerances

9.7.1 The minimum tolerance on thickness is to be as given in Table 1.4.1.

9.8 Clad plates

9.8.1 Carbon or carbon-manganese steel plates, clad on one or both surfaces with a suitable grade of austenitic or duplex stainless steel, may be used for the construction of cargo or storage tanks for chemicals.

9.8.2 The carbon or carbon-manganese steel base plates are to comply with the requirements of Section 6 and the austenitic or duplex cladding material generally with the requirements of this section.

9.8.3 The process of manufacture is to be specially approved and may be either by roll cladding or by explosive bonding.

9.8.4 Where the use of clad materials is proposed, the material specification is to be submitted for consideration, together with details of the extent and the acceptance standards for non-destructive examination.

9.9 Identification of materials

9.9.1 The particulars detailed in 1.12 are to be marked on all materials which have been accepted.

9.10 Certification of materials

9.10.1 Each test certified or shipping statement is to give the information detailed in 1.13, together with general details of heat treatment and where applicable, the results obtained from intercrystalline corrosion tests. The chemical composition is to include the content of all the elements detailed in Table 9.2.1.

Section 10

Normal and Higher Strength Corrosion Resistant Steels for Cargo Oil Tanks

10.1 Scope

10.1.1These requirements apply to normal and higher strength corrosion resistant steels when such steel is used as the alternative means of corrosion protection for cargo oil tanks as specified in the performance standard MSC.289 (87) of Regulation 3-11, Part A-1, Chapter II-1 of the SOLAS Convention (See Pt.3, Ch.2, Sec.3)

10.1.2 The requirements are primarily intended to apply to steel products with a thickness as follows:

- For steel plates and wide flats;
  - All Grades: Up to 50 [mm] in thickness
- For sections and bars;
  - All Grades: Up to 50 [mm] in thickness

10.1.3 Normal and higher strength Corrosion Resistant steels as defined within this section, are steels whose corrosion resistance performance in the bottom or top of the internal cargo oil tank is tested and approved to satisfy the requirements in MSC.289 (87) in addition to other relevant requirements for ship material, structural strength and construction. It is not intended that such steels be used for corrosion resistant applications in other areas of a vessel that are outside of those specified in the performance standard MSC.289 (87) of Regulation 3-11, Part A-1, Chapter II-1 of the SOLAS Convention.

10.1.4 The basic requirements for ship steels specified in this chapter apply to corrosion resistant steels except where modified by this section.

10.1.5 The welding requirements specified in Ch.11 for approval of consumables for welding normal and higher strength hull structural steels also apply except as modified by this section. Welding procedures are to be approved according to Pt.3, Ch.17, Sec.2.5.

10.2 Testing and Approval

10.2.1 All materials are to be manufactured at works which have been approved by IRS. .

10.2.2 The corrosion tests and assessment criteria are to be in accordance with the Appendix of the Annex to Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers (MSC.289 (87)). Approval can be given for application in one of the following areas of a cargo oil tank:

a) Lower surface of strength deck and surrounding structures.

b) Upper surface of inner bottom plating and surrounding structures.

c) For both strength deck and inner bottom plating.

10.2.3 The manufacturer has to submit to IRS a request for approval, which is to include the following:

a) Corrosion test plan and details of equipment and test environments.

b) Technical data related to product assessment criteria for confirming corrosion resistance.

c) The technical background explaining how the variation in added and controlled elements improves corrosion resistance.

d) The grades, the brand name and maximum thickness of corrosion resistant steel to be approved. Designations for corrosion resistant steels are given in Table 10.1.

e) The welding processes and the brand name of the welding consumables to be used for approval.

Table 10.1 : Designations for Corrosion Resistant Steels		
Type of steel	**Location where Steel is Used**	**Corrosion Resistant Designation**
Rolled steel for hull	For strength deck, ullage space	RCU
	For inner bottom	RCB
	For both strength deck and inner bottom plating	RCW

10.2.4 The test program submitted by the manufacturer will be reviewed by IRS, if found satisfactory, it will be approved and returned to the manufacturer for acceptance prior to tests being carried out. Tests that need to be witnessed by the IRS Surveyor will be identified.

10.2.5 Method for selection of test samples is to satisfy the following:

i. The numbers of test samples is to be in accordance with the requirements of the Appendix of the Annex to Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers (MSC.289 (87)).
ii. The number of casts and test samples selected are to be sufficient to make it possible to confirm the validity of interaction effects and/or the control range (upper limit, lower limit) of the elements which are added or intentionally controlled, for improving the corrosion resistance. Where agreed, this may be supported with data submitted by the manufacturer.
iii. Additional tests may be required by IRS when reviewing the test program against the paragraph ii.

10.2.6 In addition to paragraph 10.2.5 above, IRS may require additional tests in the following cases:

a) When IRS determines that the control range is set by the theoretical analysis of each element based on existing data, the number of corrosion resistance tests conducted in accordance with the Appendix of the Annex to Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks (MSC.289 (87)) is too few to adequately confirm the validity of the control range of chemical composition.

b) When IRS determines that the data of the corrosion resistance test result obtained for setting the control range of chemical composition varies too widely.

c) When IRS determines that the validity of the corrosion resistance test result for setting the control range of chemical composition is insufficient, or has some flaws.

d) When IRS's surveyor has not attended the corrosion resistance tests for setting the control range of chemical composition, and IRS determines that additional testing is necessary in order to confirm the validity of the test result data.

e) When IRS determines that it is necessary, for reasons other than cases (a) to (d) above.

The chemical composition of the corrosion resistant steel is to be within the range specified for rolled steel for hull. Elements to be added for improving the corrosion resistance and for which content is not specified are to be generally within 1% in total.

10.2.7 The manufacturer is to carry out the approval test in accordance with the approved test plan.

10.2.8 IRS's Surveyor is to be present, as a rule, when the test samples for the approval test are being identified and for approval tests, see also 10.2.4.

10.2.9 After completion of the approval test, the manufacturer is to produce the report of the approval test and submit to IRS.

10.2.10 IRS will give approval for corrosion resistant steel where approval tests are considered by IRS to have given satisfactory results based on the data submitted in accordance with the provisions of this section.

10.2.11 The results will be assessed by IRS in accordance with the acceptance criteria specified in the Appendix of the Annex to Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks (MSC.289 (87)).

10.2.12 It is the manufacturer's responsibility to assure that effective process and production controls in operation are adhered to within the manufacturing specifications. If the process or production controls are changed in any way, or any product fails to meet specifications, the manufacturer is to issue a report explaining the reasons, and, in the instance of product which fails to meet specifications, the measures to prevent recurrence.
The complete report is to be submitted to the Surveyor along with such additional information as the Surveyor may require. Each affected piece is to be tested to the Surveyor's satisfaction. The frequency of testing for subsequent products is at the discretion of IRS.

10.2.13 The certificate is to contain the manufacturer's name, the period of validity of the certificate, the grades and thickness of the steel approved, welding methods and consumables approved.

10.3 Method of manufacture

10.3.1 The method of manufacture, deoxidation process and rolling practice is to be in accordance with Sec. 2 for normal strength steels and Sec 3 for high strength steel.

10.4 Chemical Composition

10.4.1 The chemical composition of the samples taken from each ladle of each cast is to be determined by the manufacturer in an adequately equipped and competently staffed laboratory and is to be in accordance with the appropriate requirements mentioned in Sec. 2 for normal strength steels and Sec 3 for high strength steel.

10.4.2 The manufacturer will establish a relationship of all the chemical elements which affect the corrosion resistance, the chemical elements added or controlled to achieve this are to be specifically verified for acceptance. Verification is to be based on the ladle analysis of the steel. The manufacturer's declared analysis will be accepted subject to periodic random checks as required by the Surveyor. The carbon equivalent is to be in accordance with Sec. 2 for normal strength steels and Sec 3 for high strength steel.

10.5 Condition of supply

10.5.1 All materials are to be supplied in one of the supply conditions mentioned in Sec. 2 for normal strength steels and Sec 3 for high strength steel.

10.6 Mechanical Tests

10.6.1 Tensile testing and Charpy V-notch impact testing is to be carried out in accordance with Sec. 2 for normal strength steels and Sec 3 for high strength steel.

10.7 Freedom from defects

10.7.1 The steel is to be reasonably free from segregations and non-metallic inclusions. The finished material is to have a workmanlike finish and is to be free from internal and surface defects prejudicial to the use of the material for the intended application.

10.7.2 The acceptance criteria for surface finish and procedures for the repair of defects, as detailed in Sec1.8 and Sec.1.9 are to be observed.

10.8 Tolerances

10.8.1 Unless otherwise agreed or specially required the thickness tolerances in Sec1 are applicable.

10.9 Identification of materials

10.9.1 The steelmaker is to adopt a system for the identification of ingots, slabs and finished pieces which will enable the material to be traced to its original cast. The Surveyor is to be given full facilities for so tracing the material when required.

10.10 Inspection and testing

10.10.1 Facilities for Inspection

The manufacturer is to afford the Surveyor all necessary facilities and access to all relevant parts of the works to enable him to verify that the approved process is adhered to, for the selection of test materials, and the witnessing of tests, as required by the Rules, and for verifying the accuracy of the testing equipment.

10.10.2 Testing Procedures

The prescribed tests and inspections are to be carried out at the place of manufacture before dispatch. The test specimens and procedures are to be in accordance with Ch.2 Sec1. All the test specimens are to be selected and stamped by the Surveyor and tested in his presence, unless otherwise agreed.

10.10.3 Through Thickness Tensile Tests

If plates and wide flats with thickness of 15 mm and over are ordered with through thickness properties, the through thickness tensile test in accordance with Sec.8 is to be carried out.

10.10.4 Ultrasonic Inspection

If plates and wide flats are ordered with ultrasonic inspection, this is to be made in accordance with an accepted standard at the discretion of IRS.

10.10.5 Surface inspection and dimensions

Surface inspection and verification of dimensions are the responsibility of the steel maker. The acceptance by the IRS's Surveyor shall not absolve the steel maker from this responsibility.

10.11 Test material

10.11.1 Definitions are to be in accordance with Ch.1 Sec.1.9 and requirements for test samples are to be in accordance with Ch.1 Sec.1.7.

10.12 Test specimens

10.12.1 The dimensions, orientation and location of the Charpy V-notch impact test and tensile test specimens within the test samples are to be in accordance with Ch.2 Sec.2,and Sec3 and Ch.3 Sec 2.4 for normal strength steels.

10.12.2 The dimensions, orientation and location of the Charpy V-notch test and tensile test specimens within the test samples are to be in accordance with Ch.2 Sec.2 and Sec.3 and Ch.3, Sec. 3.4 for high strength steels.

10.13 Retest procedure

10.13.1 To be in accordance with Ch.1 Sec.1.10.

10.14 Branding

10.14.1 To be in accordance with Sec.1.12 and Table 10.1.

10.15 Documentation

10.15.1 To be in accordance with Sec.1.13.
IRS may require separate documents for each grade of steel.

End of Chapter

Chapter 4

Steel Castings

Contents

Section 1

General Requirements

1.1 Scope

1.1.1 All important steel castings, as defined in the relevant construction rules are to be manufactured and tested in accordance with the requirements of this Chapter.

1.1.2 Where required by the relevant Rules dealing with design and construction, castings are to be manufactured and tested in accordance with Ch.1 and Ch.2, together with the general requirements given in this Section and the appropriate specific requirements given in Sec.2 to 5.

1.1.3 As an alternative to 1.1.3, castings which comply with national or proprietary specifications may be accepted provided that these specifications give reasonable equivalence to the requirements of this chapter or alternatively are approved for a specific application. Generally, survey and certification are to be carried out in accordance with the requirements of Ch.1.

1.2 Manufacture

1.2.1 Castings are to be made by manufacturer approved by IRS.

1.2.2 The steel is to be manufactured by a process approved by IRS.

1.2.3 All flame cutting, scarfing or arc-air gouging to remove surplus metal is to be undertaken in accordance with recognized good practice and is to be carried out before the final heat-treatment. Preheating is to be employed when necessitated by the chemical composition and/or thickness of the castings. If necessary, the affected areas are to be either machined or ground smooth.

1.2.4 For certain components including steel castings subjected to surface hardening process, the proposed method of manufacture may require special approval by IRS.

1.2.5 When two or more castings are joined by welding to form a composite the proposed welding procedure is to be submitted for approval. Welding procedure qualification tests may be required.

1.3 Quality of castings

1.3.1 All castings are to be free from surface or internal defects which would be prejudicial to their proper application in service. The surface finish is to be in accordance with good practice and any specific requirements of the approved plan.

1.3.2 The surfaces are not to be treated in any way which may obscure defects.

1.4 Chemical composition

1.4.1 All castings are to be made from killed steel and the chemical composition is to be appropriate for the type of steel and the mechanical properties specified for the castings. The chemical composition of each heat is to be determined by the manufacturer on a sample taken preferably during the pouring to the heat. When multiple heats are tapped into a common ladle, the ladle analysis shall apply.

1.5 Inspection

1.5.1 All castings are to be cleaned and adequately prepared for examination; suitable methods include pickling, caustic cleaning, wire brushing, local grinding, shot or sand blasting. The surfaces are not to be hammered, peened or treated in any way which may obscure defects.

1.5.2 Before acceptance all castings are to be presented to the Surveyors for visual examination. Where applicable, this is to include the examination of internal surfaces. Unless otherwise agreed, the verification of dimensions is the responsibility of the manufacturer.

1.5.3 When required by the relevant construction Rules, or by the approved procedure for welded composite components appropriate non-destructive testing is also to be carried out before acceptance and the results are to be reported by the manufacturer. The castings to be examined, extent of testing and acceptance criteria are detailed in IRS Classification Notes on “Guidelines for Non-Destructive Examination of Steel Castings for Marine Application.

1.5.4 When required by the relevant construction Rules castings are to be pressure tested before final acceptance. These tests are to be carried out in the presence of the Surveyors and are to be to their satisfaction.

1.5.5 In the event of any casting proving defective during subsequent machining or testing, it is to be rejected notwithstanding any previous certification.

1.6 Hydraulic pressure testing

1.6.1 When required by the relevant construction Rules, castings are to be pressure tested before final acceptance. These tests are to be carried out in the presence of the Surveyors and are to be to their satisfaction.

1.7 Rectification of defective castings

1.7.1 General

i) Steel casting defects are to be removed with or without weld repair before considering suitable for use subject to approval of IRS.

ii) Procedure of removal of defect and weld repair is to be in accordance with IRS “Classification Notes on Guidelines for Non-Destructive Examination of Steel Castings for Marine Application.

iii) Where the defective area is to be repaired by welding, the excavations are to be suitably shaped to allow good access for welding. The resulting grooves are to be subsequently ground smooth and complete elimination of the defective material is to be verified by MT or PT.

iv) Shallow grooves or depressions resulting from the removal of defects may be accepted provided that they will cause no appreciable reduction in the strength of the casting. The resulting groves or depressions are to be subsequently ground smooth and complete elimination of the defective material is to be verified by MT or PT. Small surface irregularities sealed by welding are to be treated as weld repairs.

v) The manufacturer is to maintain full records detailing the extent and location of repairs made to each casting and details of weld procedures and heat treatments applied for repairs. These records are to be available to the Surveyor and copies provided on request.

1.7.2 Weld repairs

When it has been agreed that a casting can be repaired by welding the following requirements apply:

i) Before welding is started, full details of the extent and location of the repair, the proposed welding procedure, heat treatment and subsequent inspection procedures are to be submitted for approval:

ii) All castings in alloy steels and all castings for crankshafts are to be suitably pre-heated prior to welding. Castings in carbon or carbon-manganese steel may also require to be pre-heated depending on their chemical composition and the dimensions and position of the weld repairs.

iii) Welding s to be done under cover in positions free from draughts and adverse weather conditions by qualified welders with adequate supervision. As far as possible, all welding is to be carried out in the downhand (flat) position.

iv) The welding consumables used are to be of an appropriate composition, giving a weld deposit with mechanical properties similar and in no way inferior to those of the parent castings. Welding procedure tests are to be carried out by the manufacturer to demonstrate that satisfactory mechanical properties can be obtained after heat treatment as detailed in Sec.2.

v) After welding has been completed the castings are to be given either a suitable heat treatment in accordance with the requirements of Sec.2 or a stress relieving heat treatment at a temperature of not less than 550°C. The type of heat treatment employed will be dependent on the chemical composition of the casting and he dimensions, positions and nature of the repairs.

vi) Subject to the prior agreement of IRS special consideration may be given to the omission of postweld heat treatment or to the acceptance of local stress relieving heat treatment where the repaired area is small and machining of the casting has reached an advanced stage.

vii) On completion of heat treatment the weld repairs and adjacent material are to be ground smooth and examined by magnetic particle or liquid penetrant testing. Supplementary examination by ultrasonics or radiography may also be repaired depending on the dimensions and nature of the original defect. Satisfactory results are to be obtained from all forms of non-destructive testing used.

1.8 Identification of castings

1.8.1 The manufacturer is to adopt a system of identification which will enable all finished castings to be traced to the original cast and Surveyors are to be given full facilities for so tracing the castings when required.

1.8.2 Before acceptance, all castings which have been tested and inspected with satisfactory results are to be clearly marked by the manufacturer with the following particulars:

i) Steel quality.

ii) Identification number, cast number or other marking which will enable the full history of the casting to be traced.

iii) Manufacturer's name or trade mark.

iv) The IRS brand name 'IR'.

v) Abbreviated name of the IRS local office.

vi) Personal stamp of Surveyors responsible for inspection.

vii) Where applicable, test pressure.

1.8.3 When small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with IRS.

1.9 Certification

1.9.1 The manufacturer is to provide the Surveyor with a test certificate or shipping statement giving the following particulars for each casting or batch of castings which has been accepted:-

a) Purchaser's name and order number;

b) Description of castings and steel quality;

c) Identification number;

d) Steel making process, cast number and chemical analysis of ladle samples;

e) Results of mechanical testing;

f) General details of heat treatment;

g) Where applicable, test pressure.

Section 2

Hull and Machinery Steel Castings for General Applications

2.1 Scope

2.1.1 The requirements given in this section are applicable to steel castings intended for hull and machinery applications such as stern frames, rudder frames, crankshafts, turbine casings, bedplates, etc.

2.1.2 These requirements are applicable only to steel castings where the design and acceptance tests are related to mechanical properties at ambient temperature. For other applications, additional requirements may be necessary, especially when the castings are intended for service at low or elevated temperatures.

2.1.3 Where the use of alloy steel castings is proposed full details of the chemical composition, heat treatment, mechanical properties, testing inspection and rectification are to be submitted for approval of IRS.

2.2 Chemical composition

2.2.1 For carbon and carbon-manganese steel castings the chemical composition is to comply with the overall limits given in Table 2.2.1 or where applicable, the requirements of the approved specification.

2.2.2 Unless otherwise required, suitable grain refining elements such as aluminium may be used at the discretion of the manufacturer. The content of such elements is to be reported.

Table 2.2.1 : Chemical composition limits for hull and machinery steel castings (%)

Steel type	Applications	C (max.)	Si (max.)	Mn	S (max.)	P (max.)	Residual elements (max.)				Total residuals (max.)
							Cu	Cr	Ni	Mo	
C, C-Mn	Castings for non-welded construction	0.40	0.60	0.50 – 1.60	0.040	0.040	0.30	0.30	0.40	0,15	0.80
	Castings for welded construction	0.23	0.60	1.60 max.	0.040	0.040	0.30	0.30	0.40	0.15	0.80

2.3 Heat treatment

2.3.1 Castings are to be supplied in one of the following conditions:

Fully annealed
Normalised
Normalised and tempered
Quenched and tempered

The tempering temperature is not less than 550°C.

2.3.2 Castings or component such as crankshafts and engine bedplates, where dimensional stability and freedom from internal stresses are important are to be given a stress relief heat treatment. This is to be carried out at a temperature of not less than 550°C followed by furnace cooling to 300°C or lower.

2.3.3 Heat treatment is to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means for control and recording of temperature. The furnace dimensions are to be such as to allow the whole casting to be uniformly heated to the necessary temperature. In the case of very large castings alternative methods for heat treatment will be specially considered by IRS. Sufficient thermocouples are to be connected to the furnace charge to measure and record that its temperature is adequately uniform unless the temperature uniformity of the furnace is verified at regular intervals.

2.3.4 If a casting is locally reheated or any straightening operation is performed after the final heat treatment, a subsequent stress relieving heat treatment may be required in order to avoid the possibility of harmful residual stresses.

2.3.5 The manufacturer’s works is to maintain records of heat treatment identifying the furnace used, furnace charge, date, temperature and time at temperature. The records are to be presented to the Surveyor on request.

2.4 Mechanical tests

2.4.1 Test material, sufficient for the required tests and for possible retest purposes is to be provided for each casting or batch of castings.

2.4.2 At least one test sample is to be provided for each casting. Unless otherwise agreed these test samples are to be either integrally cast or gated to the castings and are to have a thickness of not less than 30 [mm].

2.4.3 Where the casting is of complex design or where the finished mass exceeds 10 tonnes, two test samples are to be provided. Where large castings are made from two or more casts, which are not mixed in a ladle prior to pouring, two or more test samples are to be provided corresponding, the number of the casts involved. These are to be integrally cast at locations as widely separated as possible.

2.4.4 For castings where the method of manufacture has been specially approved by IRS in accordance with 1.2.4, the number and position of test samples is to be agreed with IRS having regard to the method of manufacture employed.

2.4.5 As an alternative to 2.4.2, where a number of small castings of about the same size, each of which is under 1000 [kg] in mass are made from one cast and heat treated in the same furnace charge, a batch testing procedure may be adopted using separately cast test samples of suitable dimensions. At least one test sample is to be provided for each batch of castings.

2.4.6 The test samples are not to be detached from the casting until the specified heat treatment has been completed and they have been properly identified.

2.4.7 One tensile test specimen is to be taken from each test sample.

2.4.8 The preparation of test specimens and the procedures used for mechanical testing are to comply with the relevant requirements of Ch.2. Unless otherwise agreed all tests are to be carried out in the presence of the Surveyors.

2.5 Mechanical properties

2.5.1 Table 2.5.1 gives the minimum requirements for yield stress, elongation and reduction of area corresponding to different strength levels. Where it is proposed to use a steel with a specified minimum tensile strength intermediate to those given, corresponding minimum values for the other properties may be obtained by interpolation.

2.5.2 Castings may be supplied to any specified minimum tensile strength selected within the general limits detailed in Table 2.5.1 but subject to any additional requirements of the relevant construction rules.

2.5.3 The mechanical properties are to comply with the requirements of Table 2.5.1, appropriate to the specified minimum tensile strength or, where applicable, the requirements of the approved specification.

2.5.4 Where the result of a tensile test does not comply with the requirements, two additional tests may be taken. If satisfactory results are obtained from both of these additional tests the casting or batch of castings is acceptable. If one or both retests fail the castings or batch of castings is to be rejected.

2.5.5 The additional tests detailed in 2.5.4 are to be taken, preferably from the same, but alternatively from another, test sample representative of the casting or batch of castings.

2.5.6 At the option of the manufacturer, when a casting or batch of castings has failed to meet the test requirements, it may be reheat treated and re-submitted for acceptance tests.

Table 2.5.1 : Mechanical properties for hull and machinery steel castings

Specified minimum tensile strength (1) [N/mm^2]	**Yield stress [N/mm^2] min.**	**Elongation on 5.65 √So (%) min.**	**Reduction of area (%) min.**
400	200	25	40
440	220	22	30
480	240	20	27
520	260	18	25
560	300	15	20
600	320	13	20

Note:
(1) A tensile strength range of 150 [N/mm^2] may additionally be specified.

Section 3

Ferritic Steel Castings for Low Temperature Services

3.1 General

3.1.1 This Section gives the requirements for castings in carbon-manganese and nickel alloy steels intended for use in liquefied gas piping systems where the design temperature is lower than 0°C and for other applications where guaranteed impact properties at low temperatures is required.

3.1.2 Other steel types may also be accepted upon consideration in each case.

3.2 Chemical composition

3.2.1 The chemical composition of ladle samples is to comply with the overall limits given in Table 3.2.1. The carbon-manganese steel is to be fine grain treated.

Table 3.2.1 : Chemical composition of ferritic steel castings for low temperature service

Type of steel	Chemical composition %						
	C max.	Si max.	Mn	S max.	P max.	Ni	Residual elements max.
Carbon-manganese	0.25	0.60	0.70-1.60	0.030	0.030	0.80 max.	
$2\frac{1}{4}$ Ni	0.25	0.60	0.50-0.80	0.025	0.030	2.00-3.00	Cr 0.25 Cu 0.30 Mo 0.15 V 0.03 Total 0.60
$3\frac{1}{2}$ Ni	0.15	0.60	0.50-0.80	0.020	0.025	3.00-4.00	

3.3 Heat treatment

3.3.1 Castings are to be supplied in one of the following conditions :

a) normalized.
b) normalized and tempered.
c) quenched and tempered.

3.4 Mechanical tests

3.4.1 The mechanical properties of steel castings are to comply with requirements given in Table 3.4.1.

3.4.2 The tensile test is to be carried out at ambient temperature and the impact tests are to be carried out at the temperature specified in the table.

3.4.3 The average energy value from a set of three charpy V-notch impact test specimens is not to be lower than the required average value given in Table 3.4.1. One individual value may be less than the required average value provided that it is not less than 70 per cent of this average value.

3.5 Non-destructive testing

3.5.1 The non-destructive examination of castings is to be carried out in accordance with the appropriate requirements of 1.7 and additionally agreed between the manufacturer, purchaser and Surveyor.

Table 3.4.1 : Mechanical properties for acceptance purposes : ferritic steel castings for low temperature service							
Type of steel	**Grade**	**Yield stress [N/mm²] min.**	**Tensile strength [N/mm²]**	**Elongation on 5.65√So% min.**	**Reduction of area % min.**	**Charpy V-notch impact test**	
						Test temp.°C	**Average energy J min.**
Carbon-manganese	400 430 450	200 215 230	400 - 550 430 - 580 460 - 610	25 23 22	40 35 30	-60 (see Note)	27
$2\frac{1}{4}$ Ni	490	275	490 - 640	20	35	-70	34
$3\frac{1}{2}$ Ni	490	275	490 - 640	20	35	-95	34
Note : The temperature for carbon-maganese steels may be 5°C below the design temperature if the latter is above -55°C, with a maximum test temperature of -20°C.							

Section 4

Steel Castings for Propellers

4.1 Scope

4.1.1 These requirements are applicable to the manufacture of cast steel propellers, blades and bosses.

4.1.2 Where the use of alternative alloys is proposed, particulars of chemical composition, mechanical properties and heat treatment are to be submitted for approval.

4.1.3 These requirements may also be used for the repair of propellers damaged in service, subject to prior approval of IRS.

4.2 Manufacture

4.2.1 All propellers, blades and bosses are to be manufactured by foundries approved in accordance with Pt.2, Ch.1. The scope of the procedure tests involved in the approval is to be agreed.

4.2.2 General characteristics of castings

All castings are to have a workmanlike finish and are to be free from imperfections that could be considered to impair in-service performance.

4.2.3 Chemical composition

Typical cast steel propeller alloys are grouped into four types depending on their chemical composition as given in Table 4.2.1.

4.2.4 Heat treatment

Martensitic castings are to be austenitized and tempered. Austenitic castings should be solution treated.

4.2.5 Mechanical tests

4.2.5.1 The mechanical properties are to meet the requirements in Table 4.2.2. These values refer to the test specimens machined from integrally cast test bars attached to the hub or on the blade.

4.2.5.2 Where possible, the test bars attached on blades are to be located in an area between 0.5 to 0.6R, where R is the radius of the propeller.

4.2.5.3 The test bars are not to be detached from the casting until the final heat treatment has been carried out. Removal is to be by non-thermal procedures.

4.2.5.4 Separately cast test bars may be used subject to prior approval of IRS. The test bars are to be cast from the same heat as the castings represented and heat treated with the castings represented.

Table 4.2.1 : Typical chemical composition for steel propeller castings

Alloy type	C max. (%)	Mn max. (%)	Cr (%)	Mo[1)] max. (%)	Ni (%)
Martensitic (12 Cr 1 Ni)	0.15	2.0	11.5 - 17.0	0.5	Max. 2.0
Martensitic (13 Cr 4 Ni)	0.06	2.0	11.5 - 17.0	1.0	3.5 - 5.0
Martensitic (16 Cr 5 Ni)	0.06	2.0	15.0 - 17.5	1.5	3.5 - 6.0
Austenitic (19 Cr 11 Ni)	0.12	1.6	16.0 - 21.0	4.0	8.0 - 13.0
Note 1) Minimum values are to be in accordance with recognised national or international standards					

Table 4.2.2 : Mechanical properties for steel propeller castings

Alloy type	Proof stress $R_{p0.2}$ min. [N/mm^2]	Tensile strength R_m min. [N/mm^2]	Elongation A_5 min. (%)	Red. Of area Z min. (%)	Charpy V-notch[1]) Energy min. (J)
(12 Cr 1 Ni)	440	590	15	30	20
(13 Cr 4 Ni)	550	750	15	35	30
(16 Cr 5 Ni)	540	760	15	35	30
(19 Cr 11 Ni)	180[2)]	440	30	40	-

Notes:

1) Not required for general service and the lowest ice class notations. For other ice class notations, tests are to be made -10^{o}C.

2) $R_{p1.0}$ value is 205 [N/mm^2].

4.2.5.5 At least one set of mechanical tests is to be made on material representing each casting in accordance with Part 2, Chapter 2.

4.2.5.6 As an alternative to 4.2.5.5, where a number of small propellers of about the same size and less than 1 [m] in diameter, are made from one cast and heat treated in the same furnace charge, a batch testing procedure may be adopted using separately cast test samples of suitable dimensions. At least one set of mechanical tests is to be provided for each multiple of five castings in the batch.

4.3 Visual examination

4.3.1 All castings must be supplied in a clean fettled condition.

4.3.2 All finished castings are to be 100% visually inspected by the Surveyor. The Surveyor may require areas to be etched for the purpose of investigating weld repairs.

4.3.3 Castings are to be free from cracks, hot tears or other imperfections which, due to their nature, degree or extent, will interfere with the use of the castings.

4.4 Dimensions, dimensional and geometrical tolerances

4.4.1 The dimensions are the responsibility of the manufacturer and the report on the dimensional inspection is to be handed over to the Surveyor, who may require checks to be made in his presence.

4.4.2 Static balancing is to be carried out on all propellers in accordance with the approved drawing. Dynamic balancing may be necessary for propellers running above 500 rpm.

4.5 Non-destructive examination

4.5.1 All finished castings are subject to non-destructive testing in accordance with the requirements given in 4.5.2 to 4.5.9.

4.5.2 In order to relate the degree of non-destructive testing to the criticality of imperfections, propeller blades are divided into three severity zones designated A, B and C. Further, a distinction is made between low skew and high skew properties. (See Ch.8, Sec.3).

4.5.3 For all propellers, separately cast blades and hubs, the surfaces covered by severity Zones A, B and C are to be liquid penetrant tested. Testing of Zone A is to be undertaken in the presence of the Surveyor, whilst testing of Zone B and C may be witnessed by the Surveyor upon his request.

4.5.4 If repairs have been made either by grinding or by welding, the repaired areas are additionally to be subjected to the liquid penetrant testing independent of their location and/or severity Zone. Weld repairs are, independent of their location, always to be assessed according to Zone A.

4.5.5 The following definitions relevant to liquid penetrant indications apply:

Indication : the presence of detectable bleed-out of the penetrant liquid from the material discontinuities appearing at least 10 minutes after the developer has been applied;

Linear indication : an indication in which the length is at least three times the width;

Nonlinear indication : an indication of circular or elliptical shape with a length less than three times the width;

Aligned indication : three or more indications in a line, separated by 2 [mm] or less edge-to-edge;

Open indication : an indication that can be detected by the use of contrast dye penetrant;

Non-open indication : an indication that cannot be detected by the use of contrast dye penetrant;

Relevant indication : an indication that is caused by a condition or type of discontinuity that requires evaluation. Only indications which have any dimension greater than 1.5 [mm] shall be considered relevant.

4.5.6 For the purpose of evaluating indications, the surface is to be divided into reference areas of 100 [cm^2], which may be square or rectangular with the major dimension not exceeding 250 [mm]. The area shall be taken in the most unfavorable location relative to the indication being evaluated.

4.5.7 The indications detected may, with respect to their size and number, not exceed the values given in the Table 4.5.1.

4.5.8 Where serious doubt exists that the castings are not free from internal defects, further non-destructive inspections are to be carried out upon request of the Surveyor, e.g. radiographic and/or ultrasonic tests. The acceptance criteria are then to be agreed between the manufacturer and IRS in accordance with the recognised standard.

4.5.9 The foundry is to maintain records of inspections traceable to each casting. These records are to be reviewed by the Surveyor. The foundry is also to provide the Surveyor with a statement confirming that non-destructive tests have been carried out with satisfactory results.

Table 4.5.1 : Allowable number and size of indications depending on severity zones

Severity zone	Max. total number of indications	Indication type	Max. number for each type[1),2)]	Max. dimension of indication [mm]
A	7	Non-linear	5	4
		Linear	2	3
		Aligned	2	3
B	14	Non-linear	10	6
		Linear	4	6
		Aligned	4	6
C	20	Non-linear	14	8
		Linear	6	6
		Aligned	6	6

Table 4.5.1 (Contd.)

Notes:

1) Single non-linear indications less than 2 [mm] in Zone A and less than 3 [mm] in other zones may be disregarded.

2) The total number of non-linear indications may be increased to the maximum total number, or part thereof, represented by the absence of linear or aligned indications.

4.6 Repair

4.6.1 Defective castings are to be repaired in accordance with the requirements given in 4.6.2 to 4.6.7 and, where applicable, the requirements of 4.7.

4.6.2 In general the repairs are to be carried out by mechanical means, e.g. by grinding or milling. The resulting grooves are to be blended into the surrounding surface so as to avoid any sharp contours. Complete elimination of the defective material is to be verified by liquid penetrant testing.

4.6.3 Weld repairs are to be undertaken only when they are considered to be necessary and have prior approval of the Surveyor. All weld repairs are to be documented by means of sketches or photographs showing the location and major dimensions of the grooves prepared for welding. The documentation is to be presented to the Surveyor prior to repair welding.

4.6.4 The excavations are to be suitably shaped to allow good access for welding. The resulting grooves are to be subsequently ground smooth and complete elimination of the defective material is to be verified by liquid penetrant testing. Welds having an area less than 5 [cm^2] are to be avoided.

4.6.5 Grinding in severity Zone A may be carried out to an extent that maintains the blade thickness. Repair welding is generally not permitted in severity Zone A and will only be allowed after special consideration.

4.6.6 Defects in severity Zone B that are not deeper than t/40 [mm] ("t" is the minimum local thickness according to the Rules) or 2 [mm], whichever is greatest, are to be removed by grinding. Those defects that are deeper may be repaired by welding subject to prior approval from IRS.

4.6.7 Repair welding is generally permitted in severity Zone C.

4.7 Weld repair procedure

4.7.1 The scope of the procedure tests involved in the qualification is given in 4.10.

Before welding is started, a detailed welding procedure specification is to be submitted covering the weld preparation, welding positions, welding parameters, welding consumables, preheating, post weld heat treatment and inspection procedures.

4.7.2 All weld repairs are to be made by qualified welders using qualified procedures.

4.7.3 Welding is to be done under controlled conditions free from draughts and adverse weather.

4.7.4 Metal arc welding with electrodes or filler wire used in the procedure tests is to be used. The welding consumables are to be stored and handled in accordance with the manufacturer's recommendations.

4.7.5 Slag, undercuts and other imperfections are to be removed before depositing the next run.

4.7.6 The martenistic steels are to be furnace re-tempered after weld repair. Subject to prior approval, however, local stress relieving may be considered for minor repairs.

4.7.7 On completion of heat treatment the weld repairs and adjacent material are to be ground smooth. All weld repairs are to be liquid penetrant tested.

4.7.8 The manufacturer is to be maintain records of welding, subsequent heat treatment and inspections traceable to each casting repaired. These records are to be reviewed by the Surveyor.

4.8 Identification

4.8.1 Castings are to be clearly marked by the manufacturer in accordance with the requirements of Ch.1. The following details are to be marked on all castings which have been accepted:

a) Heat number or other marking which will enable the full history of the casting to be traced;

b) The IRS certificate number and abbreviated name of local IRS office;

c) Ice class symbol, where applicable;

d) Skew angle for high skew propellers;

e) Date of final inspection.

4.8.2 The IR stamp is to be put on when the casting has been accepted.

4.9 Certification

4.9.1 The manufacturer is to provide the Surveyor with an inspection certificate giving the following particulars for each casting which has been accepted:

a) Purchaser's name and order number;

b) Vessel identification, where known;

c) Description of the casting with drawing number;

d) Diameter, number of blades, pitch, direction of turning;

e) Skew angle for high skew propellers;

f) Final mass;

g) Alloy type, heat number and chemical composition;

h) Casting identification number;

i) Details of time and temperature of heat treatment;

j) Results of the mechanical tests.

4.9.2 The manufacturer is to provide a statement regarding non-destructive tests as required by 4.5.9 and where applicable, records of weld repairs as required by 4.7.8.

4.10 Welding procedure qualification test

4.10.1 Preparation of test assembly

A test assembly of minimum 30 [mm] thickness is to be welded. The types of specimens to be prepared are shown in Fig.4.10.1.

4.10.2 Non-destructive testing

Prior to sectioning, the test assembly is to be visually inspected and liquid penetrant tested. Imperfections shall be assessed in accordance with 4.5.

4.10.3 Macro-examination

Two macro-sections shall be prepared and etched on one side to clearly reveal the weld metal, the fusion line and the heat affected zone. The sections are to be examined by eye (aided by low power hand lens if desired) for any imperfections present in the weld metal and HAZ. Cracks or crack-like imperfections, slag inclusions and pores greater than 3 [mm] are not permitted.

4.10.4 Tensile testing

Two flat transverse tensile test specimens shall be prepared. Testing procedures shall be in accordance with Ch.4 Sec.1 requirements. The tensile strength shall meet the specified minimum value of the base material. The location of fracture is to be reported, i.e. weld metal, HAZ or base material.

4.10.5 Charpy V-notch testing

Impact test is not required, except where the base material is impact tested. Charpy V-notch test specimens shall be in accordance with Pt.2, Ch.2, Sec.3. Two sets shall be taken, one set with the notch positioned in the center of the weld and one set with the notch positioned in the fusion line, respectively.

The test temperature and impact energy shall comply with the requirement specified for the base material.

4.10.6 Hardness testing

One of the macro-sections shall be used for HV5 hardness testing. Indentations shall traverse 2 [mm] below the surface. At least three individual indentations are to be made in the weld metal, the HAZ (both sides) and in the base material (both sides). The values are to be reported for information.

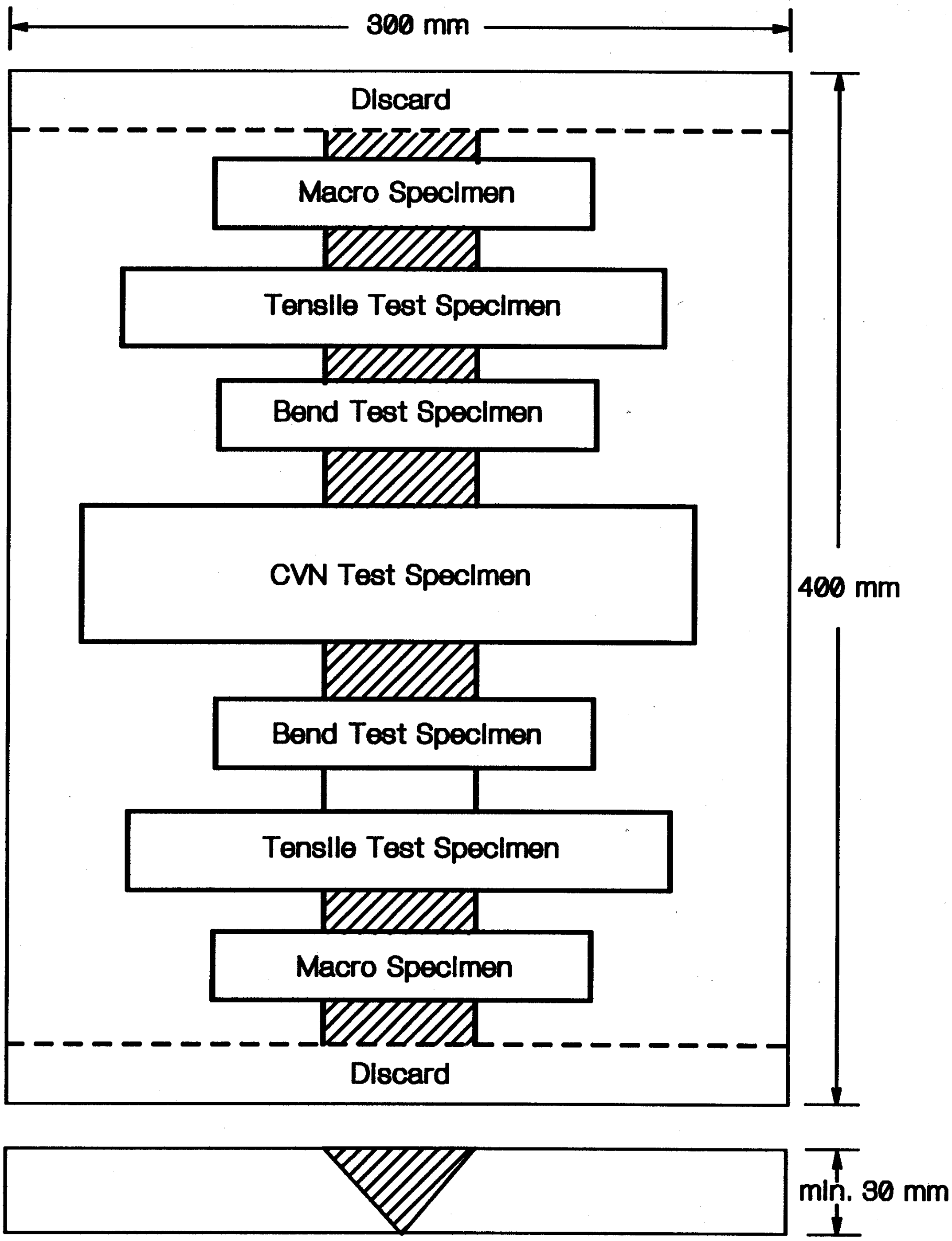


Fig.4.10.1 : Weld test assembly

Section 5

Austenitic Stainless Steel Castings

5.1 Scope

5.1.1 This section gives the requirements for castings in austenitic stainless steels for piping systems in ships for liquefied gases where the design temperature is not lower than –165°C and in bulk chemical carriers.

5.1.2 Where it is proposed to use alternative steels, particulars of the specified chemical composition, mechanical properties and heat treatment are to be submitted for approval.

5.2 Chemical composition

5.2.1 The chemical composition of ladle samples is to comply with the requirements given in Table 5.2.1.

<table>
<tr><th colspan="10">Table 5.2.1 : Chemical composition of austenitic stainless steel castings</th></tr>
<tr><th rowspan="2">Type of steel</th><th colspan="9">Chemical composition %</th></tr>
<tr><th>C max.</th><th>Si</th><th>Mn</th><th>S</th><th>P</th><th>Cr</th><th>Mo</th><th>Ni</th><th>Others</th></tr>
<tr><td>304L</td><td>0.03</td><td rowspan="6">0.20-1.5</td><td rowspan="6">0.50-2.0</td><td colspan="2" rowspan="6">0.40 max.</td><td rowspan="6">17.0-21.0</td><td>-</td><td>8.0-12.0</td><td>-</td></tr>
<tr><td>304</td><td>0.08</td><td>-</td><td>8.0-12.0</td><td>-</td></tr>
<tr><td>316L</td><td>0.03</td><td>2.0-3.0</td><td>9.0-13.0</td><td>-</td></tr>
<tr><td>316</td><td>0.08</td><td>2.0-3.0</td><td>9.0-13.0</td><td>-</td></tr>
<tr><td>317</td><td>0.08</td><td>3.0-4.0</td><td>9.0-12.0</td><td>-</td></tr>
<tr><td>347 (see Note)</td><td>0.06</td><td>-</td><td>9.0-12.0</td><td>Nb ≥8xC≤0.90</td></tr>
<tr><td colspan="10">Note: When guaranteed impact values at low temperature are not required, the maximum carbon content may be 0.08% and the maximum niobium may be 1.00%.</td></tr>
</table>

5.3 Heat treatment

5.3.1 All castings are to be solution treated at a temperature of not less than 1000°C and cooled rapidly in air, oil or water.

5.4 Mechanical tests

5.4.1 One tensile test specimen is to be prepared from material representing each casting or batch of castings. In addition, where the castings are intended for liquefied gas applications, where the design temperature is lower than –55°C, one set of three Charpy V-notch impact test specimens is to be prepared.

5.4.2 The tensile test is to be carried out at ambient temperature and the results are to comply with the requirements given in Table 5.4.2.

5.4.3 The average value for impact test specimens is to comply with the appropriate requirements given in Table 5.4.2. One individual value may be less than the required average value provided that it is not less than 70 percent of this average value. See Ch.1, 1.10 for re-test procedures.

Table 5.4.2 : Mechanical properties for acceptance purposes : austenitic stainless steel castings

Type of steel	Tensile strength [N/mm^2] minimum	1.0% proof stress [N/mm^2] minimum	Elongation on 5.65 $\sqrt{S_o}$ % minimum	Reduction of area % minimum	Charpy V-notch impact tests	
					Test temp. °C	Average energy J minimum
304L	430	215	26	40	-196	41
304	480	220				
316L	430	215	26	40	-196	41
317	480	240				
347	480	215	22	35	-196	41

5.5 Intergranular corrosion tests

5.5.1 Where corrosive conditions are anticipated in service, intergranular corrosion tests are required on castings in grades 304, 316 and 317. Such tests may not be required for grades 304L, 316L and 347.

5.5.2 Where an intergranular corrosion test is specified, it is to be carried out in accordance with the standard referred in 9.6.2 of Chapter 3.

5.6 Non-destructive examination

5.6.1 The non-destructive examination of castings is to be carried out in accordance with the appropriate requirements of Classification Notes "Guidelines for non-destructive examination of steel castings for marine application" and additionally agreed between the manufacturer, purchaser and Surveyor.

Section 6

Castings for other Applications

6.1 General

6.1.1 Details of chemical composition, heat treatment, mechanical properties of steel castings for crankshafts and those intended for elevated temperature service are to be submitted for approval of IRS.

End of Chapter

Chapter 5

Steel Forgings

Contents

Section

Section 1

General Requirements

1.1 Scope

1.1.1 All important steel forgings, as defined in the relevant construction Rules, are to be manufactured and tested in accordance with the requirements of this Chapter.

1.1.2 Where required by the relevant Rules dealing with design and construction, forgings are to be manufactured and tested in accordance with Ch.1 and 2, together with the general requirements given in this Chapter.

1.1.3 Alternatively, forgings which comply with National or proprietary specifications may be accepted provided such specifications give reasonable equivalence to these requirements or are otherwise specially approved for a specific application by IRS.

1.2 Manufacture

1.2.1 Forgings are to be made at the works approved by IRS.

1.2.2 The steel used in the manufacture of forgings is to be made by a process approved by IRS.

1.2.3 Adequate top and bottom discards are to be made to ensure freedom from piping and harmful segregations in the finished forgings.

1.2.4 The plastic deformation is to be such as to ensure soundness, uniformity of structure and satisfactory mechanical properties after heat treatment. The reduction ratio is to be in accordance with the following Table:

Method of manufacture	Total reduction ratio (See Notes 1, 2 & 3)
Made directly from ingots or forged blooms or billets	3:1 where L > D 1.5:1 where L ≤ D
Made from rolled products	4:1 where L > D 2:1 where L ≤ D
Notes 1 L and D are the length and diameter respectively of the part of the forging under consideration.	
2 the reduction ratio is to be calculated with reference to the average cross-sectional area of the ingot. Where an ingot is initially upset, this reference area may be taken as the average cross-sectional area after this operation.	
3 For rolled bars used as a substitute for forgings (see 1.1.1) the reduction ratio is not to be less than 6 : 1	
4 For forgings made by upsetting, the length after upsetting is to be not more than one-third of the length before upsetting or, in the case of an initial forging reduction of at least 1.5:1, not more than one half of the length before upsetting.	

1.2.5 For crankshafts, where grain flow is required in the most favourable direction having regard to the mode of stressing in service, the proposed method of manufacture may required special approval by IRS. In such cases, tests may be required to demonstrate that a satisfactory structure and grain flow are obtained.

1.2.6 The shaping of forgings or rolled slabs and billets by flame cutting, scarfing or arc-air gouging is to be undertaken in accordance with recognized good practice and unless otherwise approved, is to be carried out before the final heat treatment. Preheating is to be employed when necessitated by the composition and/or thickness of the steel.

1.2.7 For certain components, subsequent machining of all flame cut surfaces may be required.

1.2.8 When two or more forgings are joined by welding to form a composite component the proposed welding procedure specification is to be submitted for approval. Welding procedure qualification tests may be required.

1.3 Quality of forgings

1.3.1 All forgings are to be free from surface or internal defects which would be prejudicial to their proper application in service.

1.4 Chemical composition

1.4.1 All forgings are to be made from killed steel, and the chemical composition is to be appropriate for the type of steel, dimensions and required mechanical properties of the forgings being manufactured.

1.4.2 The chemical composition of each heat is to be determined by the manufacturer on a sample taken preferably during the pouring of the heat. When multiple heats are tapped into a common ladle, the ladle analysis is applicable.

1.5 Heat treatment (including surface hardening and straightening)

1.5.1 At an appropriate stage of manufacture, after completion of all hot working operations, forgings are to be suitably heat treated to refine the grain structure and to obtain the required mechanical properties. Heat treatment is to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means for control and recording of temperature. The furnace dimensions are to be such as to allow the whole furnace charge to be uniformly heated to the necessary temperature. In the case of very large forgings alternative methods of heat treatment will be specially considered by IRS.

1.5.2 Except as provided in 1.5.7 and 1.5.8 forgings are to be supplied in one of the following conditions:

a) Carbon and carbon-manganese steels
   Fully annealed
   Normalized
   Normalized and tempered
   Quenched and tempered

b) Alloy steels
   Quenched and tempered

For all types of steel the tempering temperature is not less than 550°C. Where forgings for gearing are not intended for surface hardening tempering at lower temperature may be allowed.

1.5.3 Alternatively, alloy steel forgings may be supplied in the normalized and tempered condition, in which case the specified mechanical properties are to be agreed with IRS.

Sufficient thermocouples are to be connected to the furnace charge to measure and record that its temperature is adequately uniform unless the temperature uniformity of the furnace is verified at regular intervals.

1.5.4 If for any reasons a forging is subsequently heated for further hot working the forging is to be re-heat treated.

1.5.5 If any straightening operation is performed after the final heat treatment, a subsequent stress relieving heat treatment to avoid harmful residual stresses is to be carried out, unless otherwise agreed.

1.5.6 Where it is intended to surface harden forgings, full details of the proposed procedure and specification are to be submitted for the approval of IRS. For the purpose of this approval, the manufacturer may be required to demonstrate by test that the proposed procedure gives a uniform surface layer of the required hardness and depth and that it does not impair the soundness and properties of the steel.

1.5.7 Where induction hardening or nitriding is to be carried out after machining, forgings are to be heat treated at an appropriate stage to a condition suitable for this subsequent surface hardening.

1.5.8 Where carburizing is to be carried out after machining, forgings are to be heat treated at an appropriate stage (generally either by full annealing or by normalising and tempering) to a condition suitable for subsequent machining and carburizing.

1.5.9 If a forging is locally reheated or any straightening operation is performed after the final heat treatment, consideration is to be given to a subsequent stress relieving heat treatment.

1.5.10 The manufacturer is to maintain records of heat treatment identifying the furnace used, furnace charge, date, temperature and time at the beginning and end of heat treatment cycle. The records are to be presented to the Surveyor on request.

1.6 Mechanical tests

1.6.1 The requirements of Mechanical tests and mechanical properties are given in Section 2 and 3.

1.7 Inspection

1.7.1 Before acceptance, all forgings are to be presented to the Surveyors for visual examination. Where applicable, this is to include the examination of internal surfaces and bores. Unless otherwise agreed, the verification of the dimensions is the responsibility of the manufacturer.

1.7.2 When required by the relevant construction Rules, or by the approved procedure for welded composite components appropriate non-destructive testing is also to be carried out before acceptance and the results are to be reported by the manufacturer.

The forgings to be examined, the extent of testing and acceptance criteria are detailed in IRS Classification Notes on “Guidelines for Non-Destructive Examination of Hull and Machinery Steel Forgings”.

1.7.3 When required by the conditions of approval for surface hardened forgings, (1.5.6) additional test samples are to be processed at the same time as the forgings which they represent. These test samples are subsequently to be sectioned in order to determine the hardness, shape and depth of the locally hardened zone and which are to comply with the requirements of the approved specification.

1.7.4 In the event of any forging proving defective during subsequent machining or testing, it is to be rejected notwithstanding any previous certification.

1.8 Rectification of defective forgings

1.8.1 Defects may be removed by grinding or chipping and grinding provided the component dimensions are acceptable.
The resulting grooves are to have a bottom radius of approximately three times the groove depth and are to be blended into the surrounding surface so as to avoid any sharp contours. Complete elimination of the defective material is to be verified by magnetic particle testing or liquid penetrant testing.

1.8.2 Repair welding of crankshaft forgings is not permitted. In the case of other forgings repair welding may be allowed subject to prior approval of IRS. In such cases, full details of the extent and location of the repair, the proposed welding procedure, heat treatment and subsequent inspection procedures are to be submitted for the approval.

1.8.3 The forging manufacturer is to maintain records of repairs and subsequent inspections traceable to each forging repaired. The records are to be presented to the Surveyor on request.

a) Purchaser's name and order number;

b) Description of forgings and steel quality identification number;

c) Steel making process, cast number and chemical analysis of ladle sample;

d) Results of mechanical tests;

e) General details of heat treatment;

f) Identification number.

1.9 Identification of forgings

1.9.1 Before acceptance, all forgings, which have been tested and inspected with satisfactory results, are to be clearly marked in at least one place with the IRS brand IR and the following particulars:

a) The manufacturer's name or trade mark;

b) Identification mark for the grade of steel;

c) Identification number and/or initials which enable the full history of the forging to be traced;

d) Personal stamp of Surveyor responsible for inspection;

e) Test pressure, where applicable;

f) Date of final inspection;

g) The 'IRS' name;

h) Abbreviated name of IRS local office.

1.9.2 Where small forgings are manufactured in large numbers, modified arrangements for identification may be specially agreed with IRS.

1.10 Certification

1.10.1 The manufacturer is to provide the Surveyor, in duplicate, with a test certificate or shipping statement giving the following particulars for each forging or batch of forgings which has been accepted:

a) Purchaser's name and order number;

b) Description of forgings and steel quality identification number;

c) Steel making process, cast number and chemical analysis of ladle sample;

d) Results of mechanical tests;

e) General details of heat treatment;

f) Identification number.

Section 2

Hull and Machinery Steel Forgings for General Applications

2.1 Scope

2.1.1 The requirements given in this section are applicable to steel forgings intended for hull and machinery applications such as rudder stocks, pintles, propeller shafts, crankshafts, connecting rods, piston rods, gearing etc. Where relevant, these requirements are also applicable to material for forging stock and to rolled bars intended to be machined into components of simple shape.

2.1.2 These requirements are applicable only to steel forgings where the design and acceptance tests relate to mechanical properties at ambient temperature. For other applications, additional requirements may be necessary especially when the forgings are intended for service at low or elevated temperatures.

2.2 Chemical Composition

2.2.1 The chemical composition is to comply with the overall limits given in Tables 2.2.1 and Table 2.2.2 or, where applicable, the requirements of the approved specification.

2.2.2 At the option of the manufacturer, suitable grain refining elements such as aluminium, niobium or vanadium may be added. The content of such elements is to be reported.

2.2.3 Elements designated as residual elements in the individual specifications are not to be intentionally added to the steel. The content of such elements is to be reported.

Table 2.2.1 : Chemical composition limits [1] for hull steel forgings [6]

Steel type	C	Si	Mn	P	S	Cr	Mo	Ni	Cu [4]	Total residuals
C, C-Mn	0.23 [2], [3]	0.45	0.20-1.50	0.035	0.035	0.30 [4]	0.15 [4]	0.40 [4]	0.30	0.85
Alloy	[5]	0.45	[5]	0.035	0.035	[5]	[5]	[5]	0.30	-

[1] Composition in percentage mass by mass maximum unless shown as a range.

[2] The carbon content may be increased above this level provided that the carbon equivalent (Ceq) is not more than 0.41%, calculated using the following formula:

$$Ceq = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} (\%)$$

[3] The carbon content of C and C-Mn steel forgings not intended for welded construction may be 0.65 maximum.

[4] Elements are considered as residual elements.

[5] Specification is to be submitted for approval.

[6] Rudder stocks and pintles should be of weldable quality.

Table 2.2.2 : Chemical composition limits [1] for machinery steel forgings

Steel type	C	Si	Mn	P	S	Cr	Mo	Ni	Cu [3]	Total residuals
C, C-Mn	0.65 [2]	0.45	0.30-1.50	0.035	0.035	0.30 [3]	0.15 [3]	0.40 [3]	0.30	0.85
Alloy [4]	0.45	0.45	0.30-1.00	0.035	0.035	Min 0.40 [5]	Min 0.15 [5]	Min 0.40 [5]	0.30	-

[1] Composition in percentage mass by mass maximum unless shown as a range or as a minimum.

[2] The carbon content of C and C-Mn steel forgings intended for welded construction is to be 0.23 maximum. The carbon content may be increased above this level provided that the carbon equivalent (Ceq) is not more than 0.41%.

[3] Elements are considered as residual elements unless shown as a minimum.

[4] Where alloy steel forgings are intended for welded constructions, the proposed chemical composition is subject to approval by IRS.

[5] One or more of the elements is to comply with the minimum content.

2.3 Mechanical tests

2.3.1 Adequate number of test coupons are to be provided for carrying out tests including for retest purposes, with a cross-sectional area of not less than that part of the forging which it represents. This test material is to be integral with each forging except as provided in 2.3.7 and 2.3.10. Where batch testing is permitted according to 2.3.10 the test material may alternatively be a production part or separately forged. Separately forged test material is to have a reduction ratio similar to that used for the forgings represented.

2.3.2 For the purpose of these requirements a set of tests is to consist of one tensile test specimen and when required in other sections of Rules three Charpy V-notch impact test specimens.

2.3.3 Test specimens are normally to be cut with their axes either parallel (longitudinal test) or tangential (tangential test) to the principal axial direction of each product.

2.3.4 Unless otherwise agreed, the longitudinal axis of test specimens is to be positioned as follows:

a) for thickness or diameter upto maximum 50 [mm], the axis is to be at the mid-thickness or the center of the cross section.
b) for thickness or diameter greater than 50 [mm], the axis is to be at one quarter thickness (mid-radius) or 8- [mm], whichever is less, below any heat treated surface.

2.3.5 Except as provided in 2.3.10 the number and direction of tests is to be as follows:

a) Hull components such as rudder stocks, pintles etc. General machinery components such as shafting, connecting rods, etc.
One set of tests is to be taken from the end of each forging in a longitudinal direction except that, at the discretion of the manufacture the alternative directions or positions as shown in Fig.2.3.5a, Fig.2.3.5b and Fig.2.3.5c may be used. Where a forging exceeds both 4 tonnes in mass and 3 [m] in length one set of tests is to be taken from each end. These limits refer to the ‘as forged’ mass and length but excluding the test material.

b) Pinions - Where the finished machined diameter of the toothed portion exceeds 200 [mm] one set of tests is to be taken from each forging in a tangential direction adjacent to the toothed portion (test position B in Fig.2.3.5d). Where the dimensions preclude the preparation of tests from this position, tests in a tangential direction are to be taken from the end of the journal (test position C in Fig.2.3.5d). If however, the journal diameter is 200 [mm] or less the tests are to be taken in a longitudinal direction (test position A in Fig.2.3.5d). Where the finished length of the toothed portion exceed 1.25 [m], one set of tests is to be taken from each end.

c) Small pinions - Where the finished diameter of the toothed portion is 200 [mm] or less one set of tests is to be taken in a longitudinal direction (test position A in Fig.2.3.5d).

d) Gear wheels - One set of tests is to be taken from each forging in tangential direction (test position A or B in Fig.2.3.5e).

e) Gear wheel rims (made by expanding)
One set of tests is to be taken from each forging in a tangential direction (test position A or B in Fig.2.3.5.f). Where the finished diameter exceeds 2.5 [m] or the mass (as heat treated excluding test material) exceeds 3 tonnes, two sets of tests are to be taken from diametrically opposite positions (test positions A and B in Fig. 2.3.5f). The mechanical properties for longitudinal test are also to be applied.

f) Pinion sleeves - One set of tests is to be taken from each forging in tangential direction (test position A or B in Fig.2.3.5g). Where the finished length exceeds 1.25 [m] one set of tests is to be taken from each end.

g) Crankwebs
One set of tests is to be taken from each forging in a tangential direction.

h) Solid open die forged crankshafts
One set of tests is to be taken in a longitudinal direction from the driving shaft end of each forging (test position A in Fig.2.3.5h).
Where the mass (as heat treated but excluding test material) exceeds 3 tonnes tests in a longitudinal direction are to be taken from each end (test positions A and B in Fig.2.3.5h). Where, however, the crankthrows are formed by machining or flame cutting, the second set of tests is to be taken in a tangential direction from material removed from the crankthrow at the end opposite the driving shaft end (test position C in Fig.2.3.5h).

2.3.6 For closed die crankshaft forgings and crankshaft forgings where the method of manufacture has been specially approved in accordance with 1.2.5, the number and position of test specimens is to be agreed with IRS having regard to the method of manufacture employed.

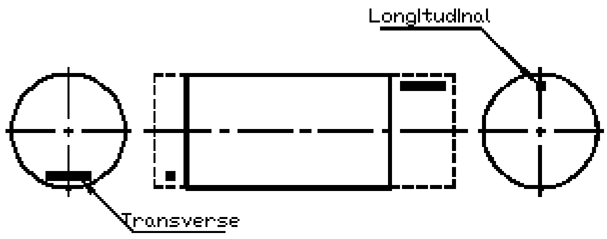


Fig.2.3.5a : Plain Shaft

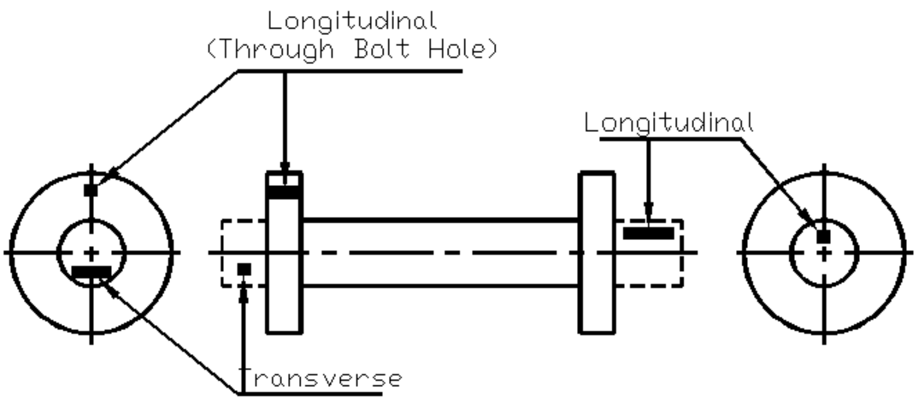


Fig. 2.3.5b : Flanged Shaft

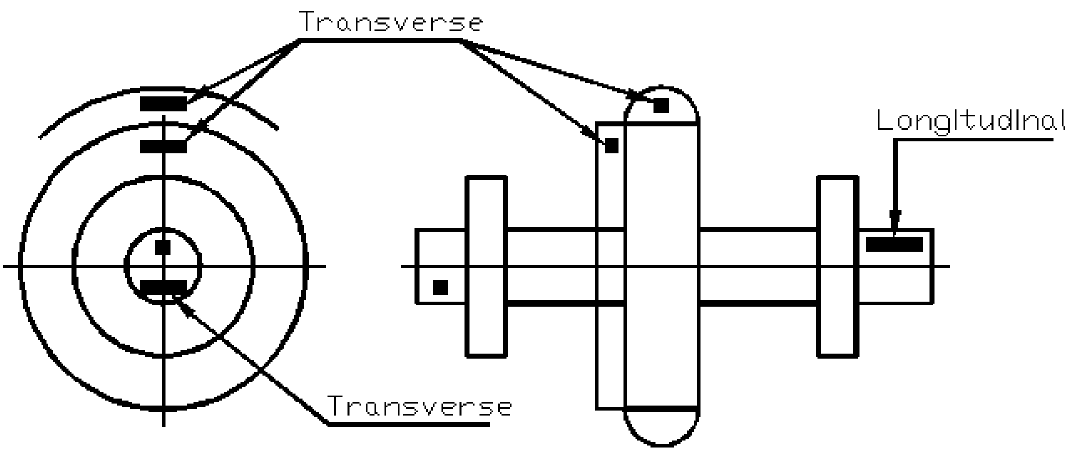
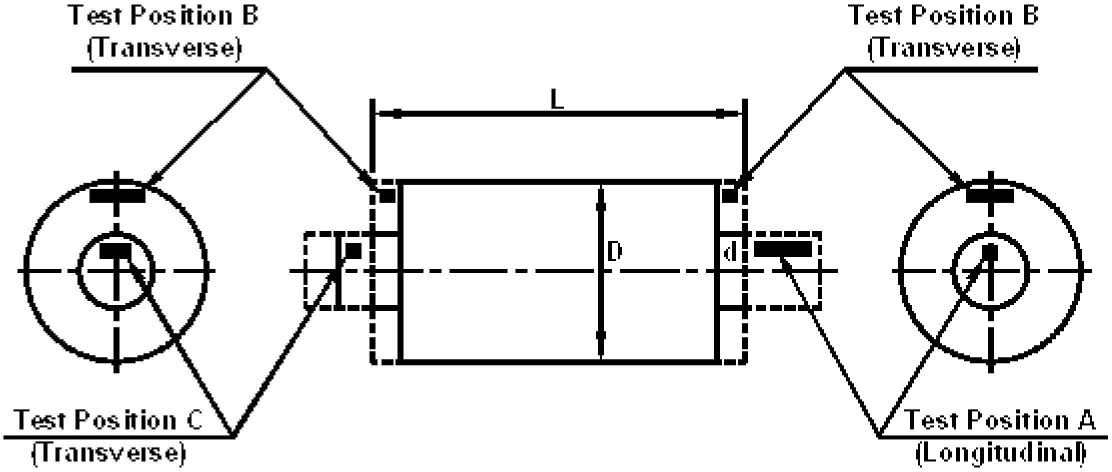


Fig.2.3.5c : Flanged shaft with collar



L = Length of Toothed Pinion (m)
D = Diameter of Toothed Pinion (m)
d = Journal Diameter

Fig.2.3.5d : Pinion

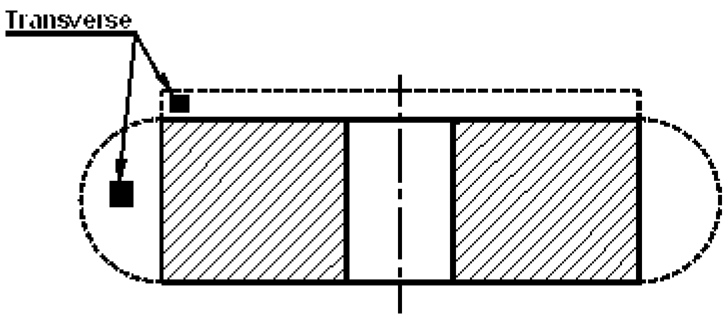


Fig.2.3.5e : Gear wheel

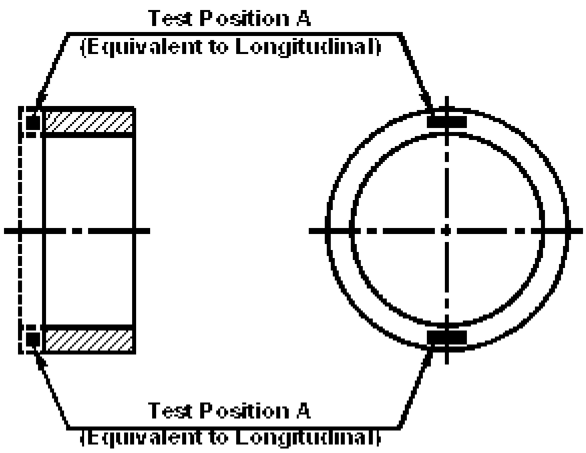


Fig.2.3.5f : Gear rim (made by expanding)

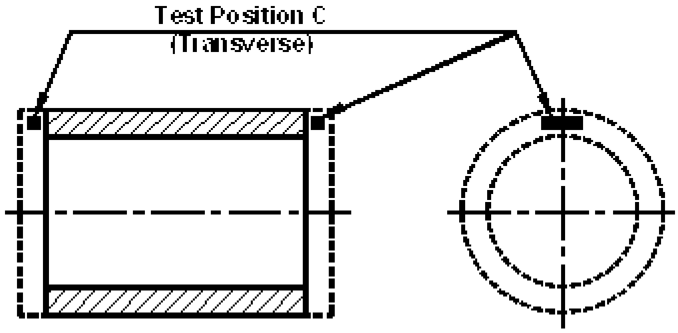


Fig.2.3.5g : Pinion sleeve

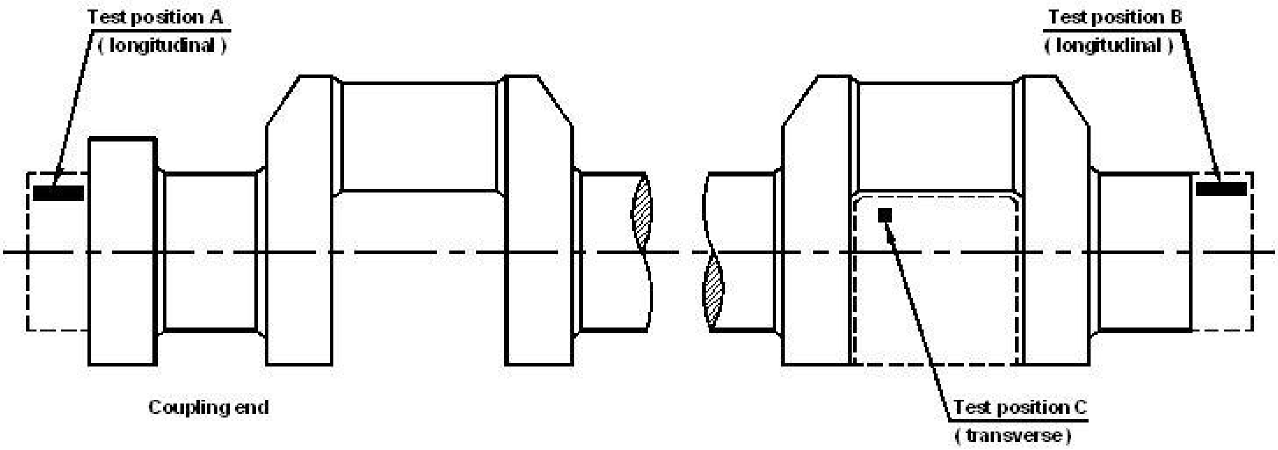


Fig.2.3.5h : Solid forged crankshaft

2.3.7 When a forging is subsequently divided into a number of components, all of which are heat treated together in the same furnace charge, for test purposes this may be regarded as one forging and the number of tests required is to be related to the total length and mass of the original multiple forging.

2.3.8 Except for components which are to be carburized or for hollow forgings where the ends are to be subsequently closed, test material is not to be cut from a forging until all heat treatment has been completed.

2.3.9 When forgings are to be carburized sufficient test material is to be provided for both preliminary tests in the as forged condition and for final tests after completion of carburizing.

For this purpose duplicate sets of test material are to be taken from positions as detailed in 2.3.5, except that irrespective of the dimensions or mass of the forging, tests are required from one position only and in the case of forgings with integral journals, are to be cut in a longitudinal direction.

This test material is to be machined to a diameter of D/4 or 60 [mm], whichever is less, where D is the finished diameter of the toothed portion.

For preliminary tests, one set of test material should be given a blank carburizing and it should undergo same heat treated cycle which the forged material will be subjected to.

For final acceptance tests, the second set of test material is to be blank carburized and heat treated along with the forgings which they represent.

At the discretion of the forge master or gear manufacturer test samples of larger cross section may be either carburized or blank carburized, but these are to be machined to the required diameter prior to the final quenching and tempering heat treatment.

Alternative procedures for testing of forgings which are to be carburized may be specially agreed with IRS.

2.3.10 Normalized forgings with mass upto 1000 [kg] each and quenched and tempered forgings with mass upto 500 [kg] each may be batch tested. A batch is to consist of forgings of similar shape and dimensions, made from the same heat of steel, heat treated in the same furnace charge and with a total mass not exceeding 6 tonnes for normalized forgings and 3 tonnes for quenched and tempered forgings respectively.

2.3.11 A batch testing procedure may also be used for hot rolled bars. A batch is to consist of either:

i) material from the same rolled ingot or bloom provided that where this is cut into individual lengths, these are all heat treated in the same furnace charge, or

ii) bars of the same diameter and heat, heat treated in the same furnace charge and with a total mass not exceeding 2.5 tonnes.

2.3.12 The preparation of test specimens and the procedures used for mechanical testing are to comply with the relevant requirements of Pt.2, Ch.2. Unless otherwise agreed all tests are to be carried out in the presence of the Surveyor.

2.4 Mechanical properties

2.4.1 Table 2.4.1 and Table 2.4.2 gives the minimum requirements for yield stress, elongation, reduction of area and impact test energy values corresponding to different strength levels but it is not tended that these should necessarily be regarded as specific grades. Where it is proposed to use a steel with a specified minimum tensile strength intermediate to those given, corresponding minimum values for the other properties may be obtained by interpolation.

2.4.2 Forgings may be supplied to any specified minimum tensile strength selected within the general limits detailed in Table 2.4.1 and Table 2.4.2 but subject to any additional requirements of the relevant construction rules.

2.4.3 The mechanical properties are to comply with the requirements of Table 2.4.1 and Table 2.4.2 appropriate to the specified minimum tensile strength or, where applicable the requirements of the approved specification.

2.4.4 At the discretion of IRS hardness tests may be required in the following cases:

i) Gear forgings after completion of heat treatment and prior to machining the gear teeth:

The hardness is to be determined at four positions equally spaced around the circumference of the surface where teeth will subsequently be cut. Where the finished diameter of the toothed portion exceeds 2.5 [m], the above number of test positions is to be increased to eight. Where the width of a gear wheel rim forging exceeds 1.25 [m], the hardness is to be determined at eight positions at each end of the forging.

ii) Small crankshaft and gear forgings which have been batch tested:

In such cases at least one hardness test is to be carried out on each forging.

The results of hardness tests are to be reported and, for information purposes, typical Brinell hardness values are given in Table 2.4.2.

2.4.5 Hardness tests may also be required on forgings which have been induction hardened, nitrided or carburized. For gear forgings these tests are to be carried out on the teeth after, where applicable, they have been ground to the finished profile. The results of such tests including depth of hardening are to comply with the approved specifications. (See 1.5.6).

2.4.6 Where the result of a tensile test does not comply with the requirements, two additional tests may be taken. If satisfactory results are obtained from both of these additional tests the forging or batch of forgings is acceptable. If one or both retests fail the forging or batch of forgings is to be rejected.

2.4.7 Where the results from a set of three impact test specimens do not comply with the requirements an additional set of three impact test specimens may be taken provided that not more than two individual values are less than the required average value and of these not more than one is less than 70% of this average value. The results obtained are to be combined with the original results to form a new average which, for acceptance of the forgings or batch forgings, is to be not less than the required average value.

Additionally, for these combined results not more than two individual values are to be less than the required average value and of these not more than one is to be less than 70% of this average value.

2.4.8 The additional tests detailed in 2.4.6 and 2.4.7 are to be taken, preferably from material adjacent to the original tests, but alternatively from another test position or sample representative of the forging or hatch of forgings.

2.4.9 At the option of the manufacturer, when a forging or a batch of forgings has failed to meet the test requirements, it may be re- heat treated and re-submitted for acceptance tests.

Table 2.4.1 : Mechanical properties for hull steel forgings

Steel type	Tensile strength 1) R_m min. [N/mm^2]	Yield stress R_e min. [N/mm^2]	Elongation as min. %		Reduction of area Z min. %	
			Long.	Tang.	Long.	Tang.
C and C-Mn	400	200	26	19	50	35
	440	220	24	18	50	35
	480	240	22	16	45	30
	520	260	21	15	45	30
	560	280	20	14	40	27
	600	300	18	13	40	27
Alloy	550	350	20	14	50	35
	600	400	18	13	50	35
	650	450	17	12	50	35

1) The following ranges for tensile strength may be additionally specified:

specified minimum tensile strength :	< 600 [N/mm^2]	≥ 600 [N/mm^2]
tensile strength range :	120 [N/mm^2]	150 [N/mm^2]

Table 2.4.2 : Mechanical properties for machinery steel forgings 2)

Steel type	Tensile strength 1) Rm min. [N/mm^2]	Yield stress Re min. [N/mm^2]	Elongation As min %		Reduction of area Z min. %		Hardness 3) (Brinell)
			Long.	Tang.	Long.	Tang.	
C and C-Mn	400	200	26	19	50	35	110-150
	440	220	24	18	50	35	125-160
	480	240	22	16	45	30	135-175
	520	260	21	15	45	30	150-185
	560	280	20	14	40	27	160-200
	600	300	18	13	40	27	175-215
	640	320	17	12	40	27	185-230
	680	340	16	12	35	24	200-240
	720	360	15	11	35	24	210-250
	760	380	14	10	35	24	225-265
Alloy	600	360	18	14	50	35	175-215
	700	420	16	12	45	30	205-245
	800	480	14	10	40	27	235-275
	900	630	13	9	40	27	260-320
	1000	700	12	8	35	24	290-365
	1100	770	11	7	35	24	320-385

Table 2.4.2 (Contd.)

1) The following ranges for tensile strength may be additionally specified:

specified minimum tensile strength :	< 600 [N/mm^2]	≥ 600 [N/mm^2]
tensile strength range :	120 [N/mm^2]	150 [N/mm^2]

2) For propeller shafts intended for ships with ice class notation except the lowest one, Charpy V-notch impact testing is to be carried out for all steel types at –10°C and the average energy value is to be minimum 27J (longitudinal test). One individual value may be less than the required average value provided that it is not less than 70% of this average value.

3) The hardness values are typical and are given for information purposes only.

Section 3

Ferritic Steel Forgings for Low Temperature Service

3.1 Scope

3.1.1 The requirements for carbon-manganese and nickel steels suitable for low temperature service are detailed in this section. They are applicable to all forgings with material thickness up to and including 50 [mm] used for the construction of cargo tanks, storage tanks and process pressure vessels for liquefied gases and where the design temperature is less than 0°C, to forgings for the piping systems.

3.1.2 The requirements are also applicable to forgings for other pressure vessels and pressure piping systems where the use of steels with guaranteed impact properties at low temperatures is required.

3.2 Chemical composition

3.2.1 The chemical composition of ladle samples is, in general, to comply with the requirements given in Table 3.2.1 of Ch.3.

3.3 Heat treatment

3.3.1 Forgings are to be normalized, normalized and tempered or quenched and tempered in accordance with the approved specification.

3.4 Mechanical tests

3.4.1 At least one tensile and three V-notch impact test specimens are to be taken from each forging or each batch of forgings. Where the dimensions and shape allow, the test specimens are to be cut in a longitudinal direction.

3.4.2 The impact tests are to be carried out at a temperature appropriate to the type of steel and for the proposed application. Where forgings are intended for ships for liquefied gases the test temperature is to be in accordance with the requirements given in Table 5.4.1 of Ch.3, Sec.5.

3.4.3 The results of all tensile tests are to comply with the approved specification.

3.4.4 The average energy values for impact tests are also to comply with the approved specification and generally with the requirements of Ch.3, Sec.5. See also Ch.2.

3.4.5 For material thickness above 50 [mm], the material properties are to be agreed.

3.5 Pressure tests

3.5.1 When applicable, pressure tests are to be carried out in accordance with the requirements of the relevant construction Rules.

Section 4

Austenitic Stainless Steel Forgings

4.1 General

4.1.1 Forgings in austenitic stainless steels are acceptable for use in the construction of cargo tanks, storage tanks and piping systems for chemicals and liquefied gases. They may also be accepted for elevated temperature service in boilers.

4.1.2 Where it is proposed to use forgings in these types of steels, details of the chemical composition, heat treatment and mechanical properties are to be submitted for approval. These are to comply in general, with the requirements of Chapter 3, Section 9 for austenitic steel plates.

4.1.3 Unless otherwise specified, impact tests are not required for acceptance purposes. Where they are required tests are to be made on longitudinal specimens at minus 196°C and the minimum average energy requirements is to be 41J.

4.2 Mechanical properties for design purposes

4.2.1 Where austenitic stainless steel forgings are intended for service at elevated temperatures, the nominal values for the minimum one per cent proof stress at temperatures of 100°C and higher given in Table 4.2.1 may be used for design purposes. Verification of these values is not required except for material complying with a National or proprietary specification in which the elevated temperature properties proposed for design purposes are higher than those given in Table 4.2.1.

4.3 Non-destructive examination

4.3.1 Non-destructive examination is to be carried out in accordance with the requirements of Classification Notes “Guidelines for non-destructive examination of hull and machinery steel forgings” or as otherwise agreed between the manufacturer, purchaser and Surveyor.

4.4 Intergranular corrosion tests

4.4.1 Where corrosive conditions are anticipated in service, intergranular corrosion tests are required on forgings in Grades 304, 316 and 317. Such tests may not be required for Grades 304L, 316L, 321 and 347.

4.4.2 When an intergranular corrosion test is specified, it is to be carried out in accordance with the standard referred in Section 9.6.2 of Chapter 3.

Table 4.2.1 : Mechanical properties for design purposes : austenitic stainless steels

Grade	Nominal 1% proof stress [N/mm^2] at a temperature												
	100°C	**150°C**	**200°C**	**250°C**	**300°C**	**350°C**	**400°C**	**450°C**	**500°C**	**550°C**	**600°C**	**650°C**	**700°C**
304L	168	150	137	128	122	116	110	108	106	102	100	96	93
316L	177	161	149	139	133	127	123	119	115	112	110	107	105
316LN	238	208	192	180	172	166	161	157	152	149	144	142	138
321	192	180	172	164	158	152	148	144	140	138	135	130	124
347	204	192	182	172	166	162	159	157	155	153	151	-	-

End of Chapter

Chapter 6

Steel Pipes and Tubes

Contents

Section

Section 1

General Requirements

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to boiler tubes, superheater tubes and pipes intended for use in the construction of boilers, pressure vessels and ship and machinery pressure piping systems.

1.1.2 In addition to specifying mechanical properties for the purpose of acceptance testing, these requirements give details of appropriate mechanical properties at elevated temperatures to be used for design purposes.

1.1.3 Except for pipes for Class III pressure systems (as defined in Pt.4, Ch.2) all pipes and tubes are to be manufactured and tested in accordance with the requirements of Ch.1 and 2 of this Part, the general requirements of this Section and the appropriate requirements given in Sec.1 to 5.

1.1.4 Steels, intended for the cargo and process piping systems of ships for liquefied gases where the design temperature is less than 0°C, are to comply with specific requirements of Sec.5.

1.1.5 Pipes and tubes, which comply with national or proprietary specifications may be accepted provided that these specifications give reasonable equivalence to the requirements of this Section or are otherwise specially approved for a specific application and provided that survey is carried out in accordance with Ch.1 of this Part.

1.1.6 At the discretion of the Surveyor, a modified testing procedure may be adopted for small quantities of materials. In such cases, these may be accepted on the manufacturer's declared chemical composition and hardness tests or other evidence of satisfactory properties.

1.1.7 Pipes for Class III pressure systems are to be manufactured and tested in accordance with the requirements of an acceptable national specification. The manufacturer's test certificate will be acceptable and is to be provided for each consignment of material. Forge butt welded pipes are not acceptable for certain applications as detailed in Pt.4, Ch.2 and Pt.5, Ch.23.

1.2 Manufacture

1.2.1 Pipes for Class I and II pressure systems, boilers and superheater tubes are to be manufactured at works approved by IRS. The steel used is to be manufactured in accordance with Ch.3, Sec.1.

1.2.2 Unless a particular method is requested by the purchaser, pipes and tubes may be manufactured by any of the following methods:-

a) hot finished seamless;

b) cold finished seamless;

c) electric resistance or induction welded;

d) cold finished electric resistance or induction welded;

e) electric fusion welded.

1.2.3 Care is to be taken during manufacture that the pipe or tube surfaces coming in contact with any non-ferrous metals or their compounds are not contaminated to such an extent as could prove harmful during subsequent fabrication and operation.

1.3 Quality

1.3.1 All pipes and tubes are to have a workmanlike finish and are to be clean and free from such surface and internal defects as can be established by the specified tests.

1.3.2 All pipes and tubes are to be reasonably straight. The ends are to be cut nominally square with the axis of the pipes or tubes, and are to be free from excessive burrs.

1.3.3 The tolerances on the wall thickness and diameter of pipes and tubes are to be in accordance with an acceptable national/ international standards.

1.4 Chemical composition

1.4.1 The requirements for the chemical composition of the ladle sample and the acceptable method of de-oxidation is to comply with the requirements detailed in the relevant Section of this Chapter.

1.5 Heat treatment

1.5.1 All pipes and tubes are to be supplied in the condition detailed in the relevant specific requirements.

1.6 Test material

1.6.1 Pipes and tubes are to be presented for test in batches. The size of a batch and the number of tests to be performed are dependent on the application.

1.6.2 Where heat treatment has been carried out, a batch is to consist of pipes or tubes of the same size, manufactured from the same type of steel and subjected to the same finishing treatment in a continuous furnace, or heat treated in the same furnace charge in a batch type furnace.

1.6.3 Where no heat treatment has been carried out, a batch is to consist of pipes or tubes of the same size manufactured by the same method from material of the same type of steel.

1.6.4 For pipes for class I pressure systems and boiler and superheater tubes, at least 2 per cent of the number of lengths in each batch is to be selected at random for the preparation of tests at ambient temperature.

1.6.5 For pipes for class II pressure systems, each batch is to contain not more than the number of lengths given in the following Table. Tests are to be carried out on at least one pipe selected at random from each batch or part thereof.

Outside diameter [mm]	Number of pipes in a batch
≤ 323.9	200 pipes as made
> 323.9	100 pipes as made

1.7 Test specimens and testing procedures

1.7.1 The procedures for mechanical tests and the dimensions of the test specimens are to be in accordance with Ch.2.

1.8 Visual and non-destructive testing

1.8.1 All pipes for Class I and II pressure systems, boiler and superheater tubes are to be presented for visual examination and verification of dimensions. The manufacturer is to provide adequate lighting conditions to enable an internal and external examination of the pipes and tubes to be carried out.

1.8.2 For welded pipes and tubes the manufacturer is to employ suitable non-destructive methods for the quality control of the welds. It is preferred that this examination is carried out on a continuous basis.

1.9 Hydraulic tests

1.9.1 Each pipe and tube is to be subjected to a hydraulic test at the manufacturer's works.

1.9.2 The hydraulic test pressure is to be determined by the following formula, except that the maximum test pressure need not exceed 14 [N/mm^2].

$$P = \frac{2st}{D}$$

where,

P = test pressure [N/mm^2];

D = nominal outside diameter [mm];

t = nominal wall thickness [mm];

s = 80 per cent of the specified minimum yield stress [N/mm^2], for ferritic steels and 70 per cent of the specified minimum 1.0 per cent proof stress [N/mm^2] for austenitic steels. These relate to the values specified for acceptance testing at ambient temperature.

1.9.3 The test pressure is to be maintained for sufficient time to permit proof and inspection. Unless otherwise agreed, the manufacturer's certificate of satisfactory hydraulic test will be accepted. Where it is proposed to adopt a test pressure other than determined as in 1.9.2, the proposal will be subject to special consideration.

1.10 Rectification of defects

1.10.1 Surface imperfections may be removed by grinding provided that the thickness of the pipe or tube after dressing is not less than the required minimum thickness. The dressed area is to be blended into the contour of the tube.

1.10.2 By agreement with the Surveyor, the repair of minor defects by welding can be accepted. Welding procedures, including preheating, post weld heat treatment and inspection, are to be to the complete satisfaction of the Surveyor. In all cases, the area is to be tested by magnetic particle examination, or in case of austenitic steels, by liquid penetrant examination on completion of welding, heat treatment and surface grinding.

1.11 Identification

1.11.1 Pipes and tubes are to be clearly marked by the manufacturer in accordance with the requirements of Ch.1. The following details are to be shown on all materials which have been accepted:-

a) IR;

b) Manufacturer's name or trade mark;

c) Identification mark for the specification or grade of steel;

d) Identification number and/or initials which will enable the full history of the item to be traced;

e) The personal stamp of the Surveyor responsible for the final inspection.

1.11.2 It is recommended that hard stamping be restricted to the end face, but it may be accepted in other positions in accordance with national standards and practices.

1.12 Certification

1.12.1 The manufacturer is to provide the Surveyor with copies of test certificate or shipping statement for all material which has been accepted.

1.12.2 Each test certificate is to contain the following particulars:-

a) Purchaser's name and order number;

b) The yard number for which the material is intended, if known;

c) Address to which material is despatched;

d) Specification or the grade of material;

e) Description and dimensions;

f) Identification number and/or initials;

g) Cast number and chemical composition of ladle samples;

h) Mechanical test results, and results of the intercrystalline corrosion tests where applicable;

i) Condition of supply.

1.12.3 The chemical composition stated on the certificate is to include the content of all the elements detailed in the specific requirements. Where rimmed steel is supplied, this is to be stated on the certificate.

1.12.4 When steel is not produced at the pipe or tube mill, a certificate is to be supplied by the steelmaker stating the process of manufacture, the cast number and the ladle analysis.

1.12.5 The works at which the steel was produced must be approved by IRS.

Section 2

Seamless Pressure Pipes

2.1 General

2.1.1 Following requirements are applicable for seamless pressure pipes in carbon, carbon-manganese and low alloy steels.

2.1.2 Where pipes are used for the manufacture of pressure vessel shells and headers, the requirements of forgings in Ch.5 are applicable where the wall thickness exceeds 40 [mm].

2.2 Manufacture and chemical composition

2.2.1 Tubes are to be manufactured by a seamless process and may be hot or cold finished.

2.2.2 The method of de-oxidation and the chemical composition of ladle samples are to comply with the appropriate requirements given in Table 2.2.1.

2.3 Heat treatment

2.3.1 Pipes are to be supplied in the condition given in Table 2.3.1.

Table 2.3.1 : Heat treatment

Type of steel	Condition of supply
Carbon and carbon-manganese	
Hot finished	Not finished[1]
	Normalized[2]
Cold finished	Normalized[2]
Alloy steels	
1 Cr $\frac{1}{2}$ Mo	Normalized and tempered
2 $\frac{1}{4}$ Cr 1 Mo	
Grade 410	Fully annealed
Grade 490	Normalized and tempered 650-750°C
$\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V	Normalized and tempered

Notes:

1. Provided that the finishing temperature is sufficiently high to soften the material.
2. Normalized and tempered at the option of the manufacturer.

Table 2.2.1 : Chemical composition of seamless pressure pipes

Type of steel	Grade	Method of deoxi-dation	Chemical composition of ladle samples %											
			C	Si	Mn	S max	P max	Residual elements						
Carbon and carbon-manganese	320	Semi-killed or killed	≤ 0.16	-	0.40 - 0.70	0.050	0.050	Ni 0.30 max., Cr 0.25 max., Mo 0.10 max., Cu 0.30 max. Total 0.70 max.						
	360		≤ 0.17	≤ 0.35	0.40 - 0.80	0.045	0.045							
	410	Killed	≤ 0.21	≤ 0.35	0.40 - 1.20	0.045	0.045							
	460	Killed	≤ 0.22	≤ 0.35	0.80 - 1.40	0.045	0.045							
	490	Killed	≤ 0.23	≤ 0.35	0.80 - 1.50	0.045	0.045							
								Ni	Cr	Mo	Cu	Sn	V	Al
1 Cr $\frac{1}{2}$ Mo	440	Killed	0.10-0.18	0.10-0.35	0.40-0.70	0.040	0.040	0.30 max.	0.70-1.10	0.45-0.65	0.25 max.	0.03 max.	-	≤ 0.020
2 $\frac{1}{4}$ Cr 1 Mo	410 490	Killed	0.08-0.15	0.10-0.50	0.40-0.70	0.040	0.040	0.30 max.	2.0-2.5	0.90-1.20	0.25 max.	0.03 max.	-	≤ 0.020
$\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V	460	Killed	0.10-0.18	0.10-0.35	0.40-0.70	0.040	0.040	0.30 max.	0.30-0.60	0.50-0.70	0.25 max.	0.03 max.	0.22 - 0.32	≤ 0.020

2.4 Mechanical tests

2.4.1 All pipes are to be presented in batches as defined in Sec.1.

2.4.2 Each pressure pipe selected for test is to be subjected to tensile and flattening or bend tests.

2.4.3 The results of all mechanical tests are to comply with the appropriate requirements given in Table 2.4.1.

2.5 Mechanical properties for design

2.5.1 Values for nominal minimum lower yield or 0.2 per cent proof stress at 50°C and higher are given in Table 2.5.1 and are intended for design purposes only. Verification of these values is not required, except for materials complying with national or proprietary specifications where the elevated temperature properties used for design are higher than those given in Table 2.5.1.

2.5.2 In such cases, at least one tensile test at the proposed design or other agreed temperature is to be made on each cast. The test specimen is to be taken from material adjacent to that used for tests at ambient temperature and tested in accordance with the procedures given in Ch.2. If tubes or pipes of more than one thickness are supplied from one cast, the test is to be made on the thickest tube or pipe.

2.5.3 As an alternative to 2.5.2, a manufacturer may carry out an agreed comprehensive test program for a stated grade of steel to demonstrate that the specified minimum mechanical properties at elevated temperatures can be consistently obtained. This test program is to be carried out under the supervision of the Surveyors, and the results submitted for assessment and approval. When a manufacturer is approved on this basis, tensile tests at elevated temperatures are not required for acceptance purposes, but at the discretion of the Surveyors, occasional check tests of this type may be requested.

2.5.4 Values for the estimated average stress to rupture in 100,000 hours are given in Table 2.5.2 and may be used for design purposes.

Table 2.4.1 : Mechanical properties for acceptance purposes : Seamless pressure pipes (maximum wall thickness 40 mm)

Type of steel	Grade	Yield stress [N/mm^2] min.	Tensile strength [N/mm^2]	Elongation on $5.65\sqrt{S_o}$% min.	Flattening test constant C	Bend test diameter of former (t = thickness)
Carbon and carbon-manganese	320	195	320-440	25	0.10	4t
	360	215	360-480	24	0.10	4t
	410	235	410-530	22	0.08	4t
	460	265	460-580	21	0.07	4t
	490	285	490-610	21	0.07	4t
1 Cr $\frac{1}{2}$ Mo	440	275	440-590	22	0.07	4t
$2\frac{1}{4}$ Cr 1 Mo	410 [1]	135	410-560	20	0.07	4t
	490 [2]	275	490-640	16	0.07	4t
$\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V	460	275	460-610	15	0.07	4t

Notes:

1 Annealed condition
2 Normalized and tempered condition

Table 2.5.1 : Mechanical properties for design purposes : Seamless pressure pipes

Type of steel	Grade	Nominal minimum lower yield or 0.2% proof stress [N/mm^2] Temperature °C											
		50	100	150	200	250	300	350	400	450	500	550	600
Carbon and carbon-manganese	320	172	168	158	147	125	100	91	88	87	-	-	-
	360	192	187	176	165	145	122	111	109	107	-	-	-
	410	217	210	199	188	170	149	137	134	132	-	-	-
	460	241	234	223	212	195	177	162	159	156	-	-	-
	490	256	249	237	226	210	193	177	174	171	-	-	-
1 Cr $\frac{1}{2}$ Mo	440	254	240	230	220	210	183	169	164	161	156	151	-
$2\frac{1}{4}$ Cr 1 Mo	410 [1]	121	108	99	92	85	80	76	72	69	66	64	62
	490 [2]	268	261	253	245	236	230	224	218	205	189	167	145
$\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V	460	266	259	248	235	218	192	184	177	168	155	148	-

Notes:

1 Annealed condition

2 Normalized and tempered condition

Table 2.5.2 : Mechanical properties for design purposes : Seamless pressure pipes - estimated values for stress to rupture in 100 000 hours (units [N/mm^2])

Temperature °C	Carbon and carbon-manganese		1 Cr $\frac{1}{2}$ Mo	2 $\frac{1}{4}$ Cr 1 Mo		$\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V
	Grade 320, 360, 410	**Grade 460, 490**	**Grade 440**	**Grade 410 Annealed**	**Grade 490 Normalized and tempered (see Note)**	**Grade 460**
380	171	227	-	-	-	-
390	155	203	-	-	-	-
400	141	179	-	-	-	-
410	127	157	-	-	-	-
420	114	136	-	-	-	-
430	102	117	-	-	-	-
440	90	100	-	-	-	-
450	78	85	-	196	221	-
460	67	73	-	182	204	-
470	57	63	-	168	186	-
480	47	55	210	154	170	218
490	36	47	177	141	153	191
500	-	41	146	127	137	170
510	-	-	121	115	122	150
520	-	-	99	102	107	131
530	-	-	81	90	93	116
540	-	-	67	78	79	100
550	-	-	54	69	69	85
560	-	-	43	59	59	72
570	-	-	35	51	51	59
580	-	-	-	44	44	46

Note : When tempering temperature exceeds 750°C, the values for Grade 410 are to be used.

Section 3

Welded Pressure Pipes

3.1 General

3.1.1 Following requirements are applicable to welded pressure pipes in carbon, carbon-manganese and low alloy steels.

3.1.2 Where it is proposed to use submerged arc longitudinally welded pipes, details of the specification are to be submitted.

3.2 Manufacture and chemical composition

3.2.1 Pipes are to be manufactured by the electric or induction welding process and, if required, may be subsequently hot reduced or cold finished.

3.2.2 The method of de-oxidation and the chemical composition of ladle samples are to comply with the appropriate requirements given in Table 3.2.1.

3.2.3 Where rimmed steel is used, the strips are to be rolled in single widths and not slit longitudinally, except to trim the edges.

Table 3.2.1 : Chemical composition of welded pressure pipes

Type of steel	Grade	Method of deoxi-dation	Chemical composition of ladle samples %										
			C	Si	Mn	S max.	P max.	Residual elements					
Carbon and carbon-manga-nese	320	Any method (see Note)	≤ 0.16	-	0.30-0.70	0.050	0.050	Ni 0.30 max., Cr 0.25 max., Mo 0.10 max., Cu 0.30 max. Total 0.70 max.					
	360		≤ 0.17	≤ 0.35	0.40-1.00	0.045	0.045						
	410	Killed	≤ 0.21	≤ 0.35	0.40-1.20	0.045	0.045						
	460	Killed	≤ 0.22	≤ 0.35	0.80-1.40	0.045	0.045						
								Ni	Cr	Mo	Cu	Sn	Al
1 Cr $\frac{1}{2}$ Mo	440	Killed	0.10-0.18	0.10-0.35	0.40-0.70	0.040	0.040	0.30 max.	0.70-1.10	0.45-0.65	0.25 max.	0.03 max.	≤ 0.020
Note : For rimmed steels the carbon content may be increased to 0.19% max.													

3.3 Heat treatment

3.3.1 Pipes are to be supplied in the heat treated condition given in Table 3.3.1.

Table 3.3.1 : Heat treatment : Welded pressure pipes

Type of steel	Condition of supply
Carbon and carbon-manganese	Normalized (Normalized and tempered at the option of the manufacturer)
1 Cr $\frac{1}{2}$ Mo	Normalized and tempered

3.4 Mechanical tests

3.4.1 All pipes are to be presented in batches as defined in Sec.1.

3.4.2 Each pressure pipe selected for test is to be subjected to tensile and flattening or bend tests.

3.4.3 The results of all mechanical tests are to comply with the appropriate requirements given in Table 3.4.1.

3.5 Mechanical properties for design

3.5.1 The mechanical properties at elevated temperature for carbon and carbon-manganese steels in Grades 320 [N/mm^2] to 460 [N/mm^2] and 1 Cr $\frac{1}{2}$ Mo steel can be taken from the appropriate Tables in Sec.2.

3.5.2 Where rimmed steel is used, the design temperature is limited to 400°C.

Table 3.4.1 : Mechanical properties for acceptance purposes : Welded pressure pipes

Type of steel	Grade	Yield stress [N/mm^2]	Tensile strength [N/mm^2]	Elongation on $5.65\sqrt{S_o}$% minimum	Flattening test constant C
Carbon and carbon-manganese	320	195	320 - 440	25	0.10
	360	215	360 - 480	24	0.10
	410	235	410 - 530	22	0.08
	460	265	460 - 580	21	0.07
1 Cr $\frac{1}{2}$ Mo	440	275	440 - 590	22	0.07

Section 4

Boiler and Superheater Tubes

4.1 General

4.1.1 The following requirements are applicable for boiler and superheater tubes in carbon, carbon-manganese and low alloy steels.

4.1.2 Austenitic stainless steels may also be used for this type of service. Where such applications are proposed, details of the chemical composition, heat treatment and mechanical properties are to be submitted for consideration and approval.

4.2 Manufacture and chemical composition

4.2.1 Tubes are to be seamless or welded and are to be manufactured in accordance with the requirements of Sec.2 and 3 respectively.

4.2.2 The method of de-oxidation and the chemical composition of ladle samples are to comply with the requirements given in Table 2.2.1 or Table 3.2.1, as appropriate.

4.3 Heat treatment

4.3.1 All tubes are to be supplied in accordance with the requirements given in Table 2.3.1 or Table 3.3.1 as appropriate, except that 1 Cr $\frac{1}{2}$ Mo steel may be supplied in the normalized only condition when the carbon content does not exceed 0.15 per cent.

4.4 Mechanical tests

4.4.1 Tubes are to be presented for test in batches as defined in Sec.1.

4.4.2 Each boiler and superheater tube selected for test is to be subjected to at least the following:

a) Tensile test;

b) Flattening or bending tests at the manufacturer's option;

c) Expanding or flanging tests at the manufacturer's option.

4.4.3 The results of all mechanical tests are to comply with the appropriate requirements given in Table 4.4.1.

4.5 Mechanical properties for design

4.5.1 The mechanical properties at elevated temperature for carbon and carbon-manganese steels in Grades 320 [N/mm^2] to 460 [N/mm^2], 1 Cr $\frac{1}{2}$ Mo and 2 $\frac{1}{4}$ Cr 1 Mo steels can be taken from the appropriate Tables in Sec.2.

4.5.2 Where rimmed steel is used, the design temperature is limited to 400°C.

Table 4.4.1 : Mechanical properties for acceptance purposes : Boilers and superheater tubes

Type of steel	Grade	Yield stress [N/mm^2]	Tensile strength [N/mm^2]	Elongation on $5.65\sqrt{S_o}$ % minimum	Flattening test constant C	Bend test diameter of former (t=thickness)	Drift expanding and flanging test minimum % increase in outside diameter. Ratio : Inside diameter / Outside diameter: $\le$ 0.6	> 0.6 $\le$ 0.8	> 0.8
Carbon and carbon-manganese	320	195	320-440	25	0.10	4t	12	15	19
	360	215	360-480	24	0.10	4t	12	15	19
	410	235	410-530	22	0.08	4t	10	12	17
	460	265	460-580	21	0.07	4t	8	10	15
1 Cr $\frac{1}{2}$ Mo	440	275	440-590	22	0.07	4t	8	10	15
2 $\frac{1}{4}$ Cr 1 Mo	410 [1]	135	410-560	20	0.07	4t	8	10	15
	490 [2]	275	490-640	16	0.07	4t	8	10	15

Notes:

1. Annealed condition
2. Normalized and tempered condition

Section 5

Tubes and Pipes for Low Temperature Services

5.1 Scope

5.1.1 This Section gives the requirements for seamless and welded carbon, carbon-manganese and nickel alloy steel pipes not exceeding 25 [mm] in thickness intended for use in liquefied gas piping systems where the design temperature is lower than 0°C and also for other pressure piping systems where guaranteed impact properties at low temperature is required.

5.2 Manufacture

5.2.1 The pipes are to be manufactured seamless or by a welding process, and may be hot or cold finished.

5.3 Chemical composition

5.3.1 The chemical composition of ladle samples is in general to comply with the requirements given in Table 5.3.1. Steels for the production of tubes and pipes are to be killed.

Table 5.3.1 : Chemical composition

Type of steel	Grade	Method of deoxi-dation	Chemical composition of ladle sample %							
			C max.	Si	Mn	P max.	S max.	Ni	Al met	Residual Elements
Carbon	360	Fully killed	0.17	0.10-0.35	0.40-1.00	0.045	0.045	-	≥ 0.015 see note	Cr 0.25 Cu 0.30 Mo 0.10 Ni 0.30 Total 0.70
Carbon-manganese	410 & 460		0.2	0.10-0.35	0.60-1.40	0.045	0.045	-	≥ 0.015 see note	
3.5 Ni	440		0.15	0.15-0.35	0.30-0.90	0.040	0.040	3.25-3.75	-	Cr 0.25 Cu 0.30 Mo 0.10 Total 0.60
9 Ni	690		0.3	0.15-0.30	0.30-0.90	0.040	0.040	8.50-9.50	-	

Note : Where a minimum Al_{met} of 0.015% is specified, the determination of the total aluminium is acceptable provided that the result is not less than 0.018%.

5.4 Heat treatment

5.4.1 Pipes are to be supplied in the condition given in Table 5.4.1.

Table 5.4.1 : Heat treatment

Type of Steel	Condition of Supply
Carbon and Carbon-manganese	Hot finished Normalized Normalized and tempered
3.5 Ni	Normalized Normalized and tempered
9 Ni	Double normalized and tempered Quenched and tempered

5.5 Mechanical tests

5.5.1 All pipes are to be presented for test in batches as defined in Sec.1 pressure piping systems.

5.5.2 At least two percent of the number of lengths in each batch is to be selected at random for the preparation of the tests.

5.5.3 Each pipe or tube selected for test is to be subjected to following tests:

- Seamless pipes and tubes:
  - one tensile test
  - one set of impact tests
  - one flattening test or bend test or ring tensile test
  - one drift or one ring expanding test where appropriate.
- Welded tubes and pipes:
  - one tensile test on the base material
  - one tensile test on the weld for pipes with D ≥ 508 [mm]
  - one set of impact tests
  - two flattening tests or bend tests or one ring tensile test (ERW and IW)
  - one drift or one ring expanding test (ERW and IW) -two bend tests (SAW).

5.5.4 Ring tensile test may be carried out in conformity with ISO 8495 or other equivalent standard.

5.5.5 The impact tests are to consist of a set of three Charpy V-notch test specimens cut in the longitudinal direction with the notch perpendicular to the original surface of the pipe. The dimension of the test specimens are to be in accordance with the requirements of Ch.2. Impact testing is not required for wall thickness below 6 [mm].

5.5.6 The impact values are to be determined at the lowest test temperature specified for the steel grade and the wall thickness in question.

5.5.7 The results of all mechanical tests are to comply with the appropriate values given in Table 5.5.1.

5.5.8 The energy value from a set of three Charpy V-notch impact test specimens is not to be lower than the required average value given in Table 5.5.1. One individual value may be less than the required average value provided that it is not less than 70 per cent of this average value.

Table 5.5.1 : Mechanical properties for acceptance purposes

Type of steel	Grade	Yield stress [N/mm^2]	Tensile strength [N/mm^2]	Elongation on 5.65 $\sqrt{S_o}$% min.	Flattening test constant C	Bend test diameter of former (t=thickness)	Charpy V-notch impact tests	
							Test temperature °C	Average energy J minimum
Carbon	360	210	360-480	24	0.10	4t	-40	27
Carbon-manganese	410	235	410-530	22	0.08	4t	-50	27
	460	260	460-580	21	0.07		-50	27
3.5 Ni	440	245	440-590	16	0.08	4t	-100	27
9 Ni	690	510	690-840	15	0.08	4t	-196	39

Section 6

Austenitic Stainless Steel Pressure Pipes

6.1 Scope

6.1.1 This section gives the requirements for austenitic stainless steel pipes suitable for use in the construction of the piping systems for chemicals and for liquefied gases where the design temperature is not less than –165°C.

6.1.2 Austenitic stainless steels are also suitable for service at elevated temperatures. Where such applications are proposed, details of the chemical composition, heat treatment and mechanical properties are to be submitted for consideration and approval. See also Pt.4, Ch.2, 1.9.5.

6.1.3 Where it is intended to supply seamless pipes in the direct quenched condition, a programme of tests for approval is to be carried out under the supervision of the Surveyors, and the results are to be to the satisfaction of IRS.

6.2 Manufacture and chemical composition

6.2.1 Pipes are to be manufactured by a seamless or a continuous automatic electric fusion welding process.

6.2.2 Welding is to be in a longitudinal direction, with or without the addition of filler metal.

6.2.3 The chemical composition of the ladle samples is to comply with the appropriate requirements of Table 6.2.1.

Table 6.2.1 : Chemical composition										
Type of steel	**Grade**	**Chemical composition of ladle sample %**								
		C max.	**Si**	**Mn**	**P max.**	**S max.**	**Cr**	**Mo**	**Ni**	**Others**
304L	490	0.03	<1.00	<2.00	0.045	0.030	17.0-19.0	-	9.0-13.0	-
316L	490	0.03	<1.00	<2.00	0.045	0.030	16.0-18.5	2.0-3.0	11.0-14.5	-
321	510	0.08	<1.00	<2.00	0.045	0.030	17.0-19.0	-	9.0-13.0	Ti ≥ 5 xC ≤ 0.80
347	510	0.08	<1.00	<2.00	0.045	0.030	17.0-19.0	-	9.0-13.0	Nb≥10 x C≤1.00

6.3 Heat treatment

6.3.1 Pipes are generally to be supplied by the manufacturer in the solution treated condition over their full length.

6.3.2 Alternatively, seamless pipes may be direct quenched immediately after hot forming, while the temperature of the pipes is not less than the specified minimum solution treatment temperature.

6.4 Mechanical tests

6.4.1 All pipes are to be presented in batches as defined in Section 1 for Class I and II piping systems.

6.4.2 Each pipe selected for test is to be subjected to tensile and flattening or bend tests.

6.4.3 The results of all mechanical tests are to comply with the appropriate requirements given in Table 6.4.1.

Where the design temperature is less than –105°C, impact tests are to be carried out on a set of three Charpy V-notch specimens. The tests are to be made on longitudinal specimens at –196°C and the average energy is to be not less than 41 Joules.

Table 6.4.1 : Mechanical properties for acceptance purposes							
Type of steel	**Grade**	**0.2% proof stress [N/mm^2] (see Note)**	**1.0% proof stress [N/mm^2]**	**Tensile strength [N/mm^2]**	**Elongation on 5.65 $\sqrt{S_o}$ % minimum**	**Flattening test constant**	**Bend test diameter of former (t=thickness)**
304L	490	175	205	490-690	30	0.09	3t
316L	490	185	215	490-690	30	0.09	3t
321	510	195	235	510-710	30	0.09	3t
347	510	205	245	510-710	30	0.09	3t
Note : The 0.2% proof stress values given for information purposes and unless otherwise agreed are not required to be verified by test.							

6.5 Intergranular corrosion tests

6.5.1 For materials used for piping systems for chemicals, intercrystalline corrosion tests are to be carried out on one per cent of the number of pipes in each batch, with a minimum of one pipe.

6.5.2 For pipes with an outside diameter not exceeding 40 [mm], the test specimens are to consist of a full cross section. For larger pipes, the test specimens are to be cut as circumferential strips of full wall thickness and having a width of not less than 12.5 [mm]. In both cases, the total surface areas is to be between 15 and 35 [cm^2].

6.5.3 When required, one test of this type is to be carried out for each tensile test. The testing is to be carried out in accordance with ASTM A262, practice E, copper-copper sulphate-sulphuric acid or another recognized standard. The bent specimen is to be free from cracks indicating the presence of intergranular attack. The material for the test is to be taken adjacent to that for the tensile test.

6.5.4 After immersion, the full cross-section test specimens are to be subjected to a flattening test in accordance with the requirements of Chapter 2. The strip test specimens are to be subjected to a bend test through 90° over a mandrel of diameter equal to twice the thickness of the test specimen.

6.6 Fabricated pipework

6.6.1 Fabricated pipework is to be produced from material manufactured in accordance with 6.2, 6.3, 6.4 and 6.5.

6.6.2 Welding is to be carried out in accordance with an approved and qualified procedure by suitably qualified welders.

6.6.3 Fabricated pipework may be supplied in the as-welded condition without subsequent solution treatment provided that welding procedure tests have demonstrated satisfactory material properties including resistance to intercrystalline corrosion.

6.6.4 In addition, butt welds are to be subjected to 5 per cent radiographic examination for Class I and 2 per cent for Class II pipes.

6.6.5 Fabricated pipework in the as-welded condition and intended for systems located on deck is to be protected by a suitable corrosion control coating.

End of Chapter

Chapter 7

Iron Castings

Contents

Section

Section 1

General Requirements

1.1 Scope

1.1.1 This Chapter gives the requirements for both grey and spheroidal or nodular graphite iron castings intended for ship and machinery construction.

1.1.2 All important iron castings, as defined in the relevant parts of the Rules dealing with design and construction, are to be manufactured and tested in accordance with the requirements of Ch.1 and 2 and the requirements given in the following paragraphs.

1.1.3 As an alternative to 1.1.2, castings which comply with National or Proprietary specifications may be accepted, provided that such specifications give reasonable equivalence to these requirements or otherwise are specially approved or required by IRS.

1.1.4 Where small castings are produced in large quantities, the manufacturer may adopt alternative procedure for testing and inspection, subject to the approval of IRS.

1.1.5 These requirements are applicable only to castings where the design and acceptance tests are related to mechanical properties at ambient temperature. For other applications additional requirements may be necessary, especially when the castings are intended for service at low or elevated temperatures.

1.2 Manufacture

1.2.1 All castings, as designated in1.1.2, are to be manufactured at foundries approved by IRS.

1.2.2 Suitable mechanical methods are to be employed for the removal of surplus material from the castings. Thermal cutting processes are not acceptable, except as a preliminary operation to the mechanical methods.

1.2.3 Where castings of the same type are regularly produced in quantity, the manufacturer is to make any tests necessary to prove the quality of the prototype castings and is also to make periodical examinations to verify the continued efficiency of the manufacturing technique. The Surveyor is to be given the opportunity to witness these tests.

1.3 Quality of castings

1.3.1 Castings are to be free from surface or internal defects which could be prejudicial to their proper application in service. The surface finish is to be in accordance with good practice and any specific requirements of the approved plan.

1.4 Chemical composition

1.4.1 The chemical composition of the iron used is left to the discretion of the manufacturer, who is to ensure that it is suitable to obtain the mechanical properties specified for the castings.

1.5 Heat treatment

1.5.1 Except as required by 1.5.2, castings may be supplied in either the as cast or heat treated condition.

1.5.2 For some applications, such as high temperature service or where dimensional stability is important, castings may be required to be given a suitable tempering or stress relieving heat treatment. This is to be carried out after any refining heat treatment and before machining. The special qualities with 350 [N/mm^2] and 400 [N/mm^2] nominal tensile strength and impact test are to undergo ferritizing heat treatment.

1.5.3 Where it is proposed to locally harden the surface of castings, full details of the proposed procedure and specifications are to be submitted for approval by IRS.

1.6 Mechanical tests

1.6.1 Separately cast test samples are to be used unless otherwise agreed between the manufacturer and the purchaser. The test samples are generally to be one of the standard types detailed in Fig.1.6.1, Fig.1.6.2 and Fig.1.6.3 with a thickness of 25 [mm]. Test samples of dimensions, other than as detailed in Fig.1.6.1 to Fig.1.6.3 may, however, be specially required for some components. For grey cast iron the test samples are to be in the form of cylindrical bars of 30 [mm] diameter and of suitable length. When two or more test samples are cast simultaneously in a single mould, the bars are to be at least 50 [mm] apart as indicated in Fig.1.6.4.

1.6.2 Integrally cast samples may be used when a casting is more than 20 [mm] thick and its mass exceeds 200 [kgs] subject to agreement between the manufacturer and the purchaser. The type and location of the test sample are to be selected to provide approximately the same cooling conditions as for the casting it represents.

1.6.3 At least one test sample is to be provided for each casting or batch of castings. A batch consists of castings poured from a single ladle of metal provided they are all of similar type and dimensions. A batch should not normally exceed two tonnes of fettled castings and a single casting will constitute a batch if its mass is two tonnes or more.

1.6.4 For continuous melting of same grade of cast iron in large tonnages the mass of the batch may be increased to the output of two hours of pouring. If production is carefully monitored by systematic checking of the melting process, such as chill testing, chemical analysis or thermal analysis, test samples may be taken at longer intervals.

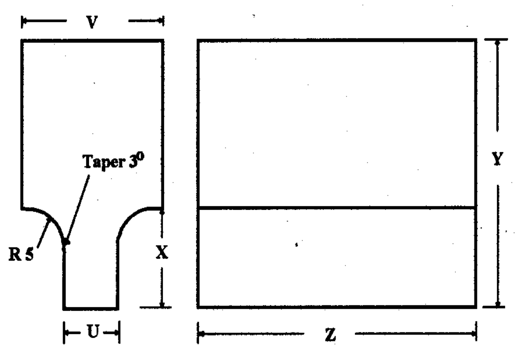
1.6.5 For large castings where more than one ladle of treated metal is used, additional test samples are to be provided so as to be representative of each ladle used.

1.6.6 All test samples are to be suitably marked to identify them with the castings which they represent.

1.6.7 Where castings are supplied in the heat treated condition, the test samples are to be heat treated together with the castings which they represent.

1.6.8 The test samples are to be cast in moulds made from the same type of material as used for the castings and are not to be stripped from the moulds until the metal temperature is below 500°C.

1.6.9 One tensile test specimen is to prepared from each test sample. The dimensions of the test specimens and the testing procedures used are to be in accordance with Ch.2.



Standardsample		Alternative samples, when required		
U	25	12	50	75
V	55	40	90	125
X	40	30	60	65
Y	100	80	150	185
Z	To suit testing machine (approx. 150 [mm])			

Fig.1.6.1 : Standard test specimen

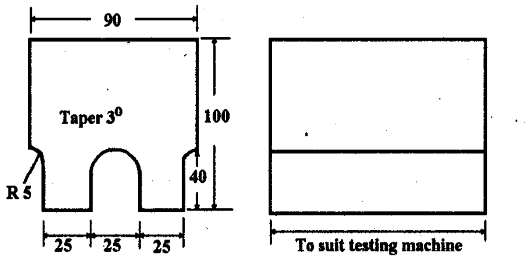
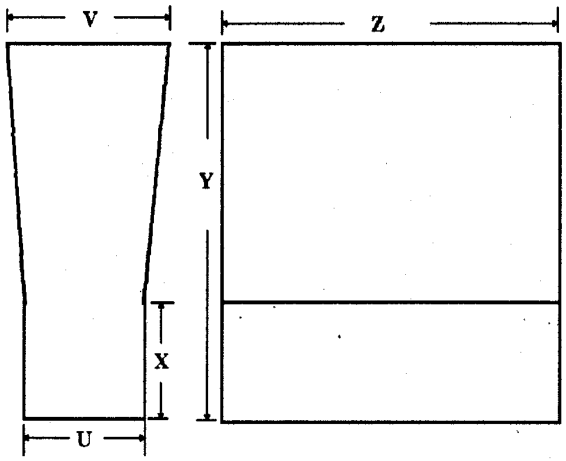


Fig.1.6.2 : Standard test specimen



Standardsample		Alternative samples, when required		
U	25	12	50	75
V	55	40	90	125
X	40	25	50	65
Y	140	135	150	175
Z	To suit testing machine (approx. 150 [mm])			

Fig.1.6.3 : Standard test specimen

Dimensions in millimeters

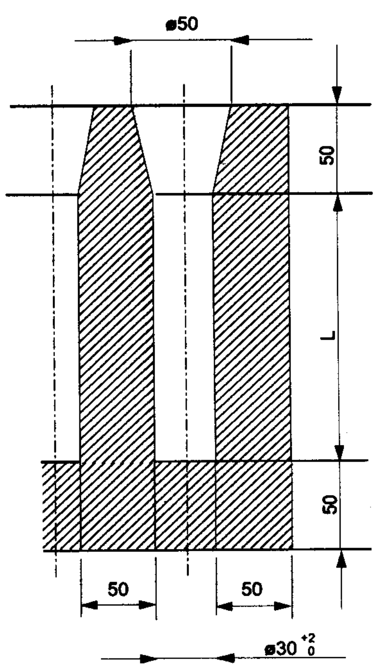


Fig.1.6.4 : Test sample for grey cast iron

1.7 Mechanical properties

1.7.1 For grey iron castings, only the tensile strength is to be determined and the results obtained are to comply with the minimum value specified for the castings being supplied. The specified minimum tensile strength is to be not less than 200 [N/mm^2] and not more than 350 [N/mm^2]. The fractured surfaces of all tensile test specimens are to be granular and grey in appearance.

1.7.2 For spheroidal or nodular graphite iron castings the tensile strength and elongation are to be determined. The results of all tests are to comply with the requirements of Table 1.7.1, but subject to any additional requirements of the relevant construction rules. Typical ranges of hardness values are also given in Table 1.7.1 and are intended for information purposes.

1.7.3 Retest requirements for tensile tests are to be in accordance with 1.10 of Chapter 1.

1.8 Visual and non-destructive examination

1.8.1 All castings are to be cleaned and adequately prepared for examination. The surfaces are not to be hammered, peened or treated in any way which may obscure defects.

Table 1.7.1 : Mechanical properties for acceptance purposes (spheroidal or nodular graphite iron)

Specified Minimum Tensile Strength [N/mm^2]		0.2% proof stress (see Note) [N/mm^2]	Elongation on $5.65\sqrt{S_o}$ % min.	Typical Hardness Brinell (see para 1.7.2)	Impact Energy Test Temp. °C	Impact Energy J Min.[2]	Typical structure of matrix (see para 1.9.2)
Ordinary qualities	370	230	17	120 - 180	-	-	Ferrite
	400	250	12	140 - 200	-	-	Ferrite
	500	320	7	170 - 240	-	-	Ferrite/Pearlite
	600	370	3	190 - 270	-	-	Ferrite/Pearlite
	700	420	2	230 - 300	-	-	Pearlite
	800	480	2	250 - 350	-	-	Pearlite or Tempered Structure
Special qualities	350	220	22[3]	110 - 170	20	17(14)	Ferrite
	400	250	18[3]	140 - 200	20	14(11)	Ferrite

Notes:

1. For intermediate values of specified minimum tensile strength, the minimum values for 0.2% proof and elongation may be obtained by interpolation.
2. The average value measured on 3 Charpy V-notch specimens. One result may be below the average value but not less than the minimum shown in brackets.
3. In the case of integrally cast samples, the elongation may be 2 percentage points less.

1.8.2 Before acceptance, all castings are to be visually examined including, where applicable, the examination of internal surfaces. Unless otherwise agreed the verification of dimensions is the responsibility of the manufacturer.

1.8.3 Supplementary examination of castings by suitable non-destructive testing procedures is generally not required except in circumstances where there is reason to suspect the soundness of the casting.

1.8.4 When required by the relevant construction Rules, castings are to be pressure tested before final acceptance.

1.8.5 Cast crankshafts are to be subjected to a magnetic particle inspection. Crack like indications are not permitted.

1.9 Metallographic examination

1.9.1 For spheroidal or nodular graphite iron castings, a representative sample from each ladle of treated metal is to be prepared for metallographic examination. These samples may conveniently be taken from the tensile test specimens but alternative arrangement for the provision of the samples may be adopted provided that they are taken from the ladle towards the end of the casting period.

1.9.2 Examination of the samples is to show that at least 90 per cent of the graphite is in a dispersed spheroidal or nodular form. Details of the typical matrix structure are given in Table 1.7.1 and are intended for information purposes only.

1.10 Rectification of defective castings

1.10.1 At the discretion of the Surveyor, small surface blemishes may be removed by local grinding.

1.10.2 Subject to the prior approval of the Surveyor, castings containing local porosity may be rectified by impregnation with a suitable plastic filler, provided that the extent of the porosity is such that it does not adversely affect the strength of the castings.

1.10.3 Repairs by welding are generally not permitted, but may be considered in special circumstances. In such cases, full details of the proposed repair procedure are to be submitted for approval prior to commencement of the proposed rectification.

1.11 Identification of castings

1.11.1 The manufacturer is to adopt a system of identification which will enable all finished castings to be traced to the original ladle of treated metal and the Surveyor is to be given full facilities for so tracing the castings when required.

1.11.2 Before acceptance, all castings which have been tested and inspected with satisfactory results are to be clearly marked by the manufacturer with the following particulars:-

a) Grade of cast iron;

b) Identification number, or other marking which will enable the full history of the casting to be traced;

c) Manufacturer's name or trade mark;

d) IR and the abbreviated name of the local office of IRS;

e) Personal stamp of the Surveyor responsible for inspection;

f) Where applicable, test pressure;

g) Date of final inspection.

1.11.3 Where small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with IRS.

1.12 Certification

1.12.1 The manufacturer is to provide the Surveyor with a written statement giving the following particulars for each casting or batch of castings which has been accepted:-

a) Purchaser's name and order no;

b) Description of castings and quality of cast iron;

c) Identification number;

d) Results of mechanical tests;

e) Where applicable, details of heat treatment;

f) Where specially required, the chemical analysis of the ladle sample;

g) Where applicable, test pressure.

End of Chapter

Chapter 8

Copper Alloys

Contents

Section 1

General Requirements

1.1 Scope

1.1.1 The Rules in this Chapter apply to copper alloys used in castings for valves and fittings, propeller castings and tubes.

1.1.2 When required by the relevant parts of the Rules, dealing with design and construction, tubes and castings are to be manufactured and tested in accordance with the appropriate requirements of Ch.1 and 2 and the requirements of this Chapter.

1.1.3 Alternatively, tubes and castings which comply with National or proprietary specifications may be accepted provided these specifications give reasonable equivalence to the requirements of this Chapter and provided that survey is carried out in accordance with the requirements of Ch.1.

1.1.4 Where it is proposed to use an alloy which is not specified in this Chapter, details of chemical composition, heat treatment and mechanical properties are to be submitted for approval.

Section 2

Castings for Valves and Fittings

2.1 Scope

2.1.1 Following requirements make provision for copper alloy castings for valves, liner bushes and other fittings intended for use in ship and machinery construction.

2.2 Manufacture

2.2.1 Approval of Works, as required by Ch.1, for the manufacture of castings, covered by this Section, is not required.

2.3 Quality of castings

2.3.1 All castings are to be free from surface or internal defects, which could be prejudicial to their proper application in service.

2.4 Chemical composition

2.4.1 The chemical composition is to comply with the appropriate requirements of Table 2.4.1.

2.4.2 Where a cast is wholly prepared from ingots for which an analysis is already available, and provided that no significant alloy additions are made during melting, the ingot maker's certified analysis may be accepted subject to occasional check tests as requested by the Surveyors.

Table 2.4.1 : Chemical composition

Designation	Chemical composition %								
	Cu	Sn	Zn	Pb	Ni	Mn	P	Fe	Al
90/10 Cu-Sn Phosphor-bronze	Remainder	9.0-11.0	0.5 max.	0.75 max.	0.5 max.	-	0.50 max.	-	-
85/5/10 Leaded bronze	Remainder	4.0-6.0	2.0 max.	9.0-11.0	2.0 max.	-	0.10 max.	-	-
88/10/2 Gunmetal	Remainder	8.5-11.0	1.0-3.0	1.5 max.	1.0 max.	-	-	-	-
87/7/3/3 Leaded Gunmetal	Remainder	6.0-8.0	1.5-3.0	2.5-3.5	2.0 max.	-	-	-	-
85/5/5/5 Leaded Gunmetal	Remainder	4.0-6.0	4.0-6.0	4.0-6.0	2.0 max.	-	-	-	-
70/30 Cu-Ni-Fe	Remainder	-	-	-	29.0-32.0	0.5-1.50	-	0.4-1.0	-
90/10 Cu-Ni-Fe	Remainder	-	-	-	9.0-11.0	0.5-1.0	-	1.0-1.8	-
Ni-Al-bronze	Remainder	0.10 max.	1.0 max.	0.03 max.	3.0-6.0	0.5-4.0	-	2.0-6.0	7.0-11.0

2.5 Heat treatment

2.5.1 At the option of the manufacturer castings may be supplied in the 'as cast' or heat treated condition.

2.6 Mechanical tests

2.6.1 The test material may be separately cast as a keel block sample in accordance with Fig.3.6.1 or as otherwise agreed with the Surveyor. For liners and bushes, the test material may be cut from the ends of the casting.

2.6.2 Where castings are supplied in a heat treated condition, the test samples are to be similarly heat treated prior to the preparation of the tensile specimens.

2.6.3 The results of all tests are to comply with the appropriate requirements given in Table 2.6.1.

2.7 Visual examination

2.7.1 All castings must be supplied in a clean fettled condition.

2.7.2 Before acceptance, all castings are to be presented for visual examination by the Surveyor. This is to include the examination of internal surfaces where applicable.

2.7.3 The accuracy and verification of dimensions are the responsibility of the manufacturer, unless otherwise agreed.

2.8 Pressure testing

2.8.1 Where required by the relevant construction Rules, castings are to be pressure tested before final acceptance. Unless otherwise agreed, these tests are to be carried out in the presence of the Surveyors and are to be to their satisfaction.

Table 2.6.1 : Mechanical properties for acceptance purposes

Designation	0.2% proof stress [N/mm^2] minimum (see Note)	Tensile Strength [N/mm^2] minimum	Elongation on $5.65\sqrt{S_o}$% minimum
90/10 Cu-Sn Phosphor-bronze	120	250	15
85/5/10 Leaded bronze	100	200	16
88/10/2 Gunmetal	130	270	13
87/7/3/3 Leaded Gunmetal	130	250	16
85/5/5/5 Leaded Gunmetal	100	200	16
70/30 Cu-Ni-Fe	220	420	20
90/10 Cu-Ni-Fe	160	320	20
Ni-Aluminium bronze	240	590	16

Note:

The 0.2% proof stress values are given for information purposes only and, unless otherwise agreed, are not required to be verified by test.

2.9 Rectification of defective castings

2.9.1 Minor surface defects may be removed by grinding provided that the dimensional tolerances are not exceeded.

2.9.2 Proposal to repair a defective casting by welding are to be submitted to the Surveyor for approval before this work is commenced. Such proposals are to include details of the extent and positions of all defects. The Surveyor is to satisfy himself the number and size of the defects are such that castings can be efficiently repaired.

2.9.3 A statement and/or sketch detailing the extent and position of all weld repairs is to be prepared by the manufacturer as permanent record.

2.9.4 Weld repairs to liners in copper alloys containing more than 0.5 per cent lead are not permitted.

2.10 Identification

2.10.1 Before acceptance, all castings which have been tested and inspected with satisfactory results are to be clearly marked with the following details:

a) Identification number, cast number or other markings which will enable the full history of the casting to be traced;

b) IR and the abbreviated name of the IRS local office;

c) Personal stamp of the Surveyor responsible for inspection;

d) Test pressure, where applicable;

e) Date of final inspection.

2.10.2 Where small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with the Surveyor.

2.11 Certification

2.11.1 The manufacturer is to provide the Surveyor with a written statement giving the following particulars for each casting or batch of castings which has been accepted:-

a) Purchaser's name and order no.;

b) Description of castings and alloy type;

c) Identification number

d) Type of heat treatment, where applicable;

e) Ingot or cast analysis.

2.11.2 In addition to 2.11.1 the manufacturer is to provide a signed statement and/or sketch detailing the extent and position of all weld repairs made to each casting.

Section 3

Castings for Propellers

3.1 Scope

3.1.1 Following requirements make provision for propeller and propeller blade castings in copper alloys.

3.2 Manufacture

3.2.1 All castings are to be manufactured at foundries approved by IRS in accordance with the appropriate requirements of Ch.1.

3.2.2 An application for approval is to be made to IRS supported by following information:

- Specification of the propeller materials;
- Manufacturing procedures;
- Repair methods;
- NDT inspection procedures;

- Description of the foundry facilities including the maximum capacity of the ladles.

3.2.3 The extent of tests required for approval is to be agreed upon with IRS. The approval is based on verifying that the chemical and physical properties of the cast test coupons of the propeller material in question comply with the rules.

3.2.4 The foundry is to have an adequately equipped approved laboratory manned by experienced personnel for carrying out chemical analysis, mechanical testing and microstructure examination of the representative cast test coupons. Provision is also to be made for NDT inspection, if these test facilities are not available at the foundry then details are to be submitted of an approved local laboratory which will provide such services.

3.3 Quality of castings

3.3.1 All castings must have a workmanlike finish and are to be free from surface or internal defects which would be prejudicial to their proper application in service. Minor casting defects which may still be visible after machining such as small sand and slag inclusions, cold shuts and scabs are to be trimmed off by the manufacturer.

3.4 Chemical composition

3.4.1 The chemical composition of samples from each cast is to comply with the requirements given in Table 3.4.1.

3.4.2 The manufacturer is to maintain permanent records of all chemical analysis, which are to be made available to the Surveyor for verifying that the chemical composition of each casting is within the specified limits.

3.4.3 When a cast is wholly prepared from ingots for which an analysis is already available, and provided that no significant alloy additions are made during melting, the ingot maker's certified analysis can be accepted subject to occasional checks as required by the Surveyor.

3.4.4 It is recommended for alloys Grade Cu 1 and Cu 2 that the zinc equivalent is not to exceed 45 percent and is to be calculated using the following formula:

$$\text{Zinc equivalent} = 100 - \frac{100 \text{ x } \%\text{Cu}}{100 + \text{A}}$$

where A is the algebraic sum of the following:

1 x % Sn

5 x % Al

- 0.5 x % Mn

- 0.1 x % Fe

- 2.3 x % Ni.

Table 3.4.1 : Chemical composition of propeller and propeller blade castings

Alloy Designation	Chemical composition of ladle samples %							
	Cu	**Sn**	**Zn**	**Pb**	**Ni**	**Fe**	**Al**	**Mn**
Grade Cu1 Manganese Bronze (high strength brass)	52 - 62	1.5 max.	35 - 40	0.5 max.	1.0 max.	0.5-2.5	0.5-3.0	0.5-4.0
Grade Cu2 Ni-Manganese Bronze (high strength brass)	50 - 57	1.5 max.	33 - 38	0.5 max.	3.0-8.0	0.5-2.5	0.5-2.0	1.0-4.0
Grade Cu3 Ni-Aluminium Bronze	77 - 82	0.1 max.	1.0 max.	0.03 max.	3.0-6.0	2.0-6.0	7.0-11.0	0.5-4.0
Grade Cu4 Mn-Aluminium Bronze	70 - 80	1.0 max.	6.0 max.	0.05 max.	1.5-3.0	2.0-5.0	6.5-9.0	8.0-20.0

3.5 Heat treatment

3.5.1 At the option of the manufacturer, castings may be supplied in the 'as cast' or heat treated condition.

3.6 Mechanical tests

3.6.1 Test samples are to be provided from each cast used for the manufacture of propeller or propeller blade castings.

3.6.2 The test samples are to be of the keel block type, generally in accordance with the dimensions given in Fig.3.6.1 or as agreed with the Surveyor and are to be cast in moulds made from the same type of material as used for castings.

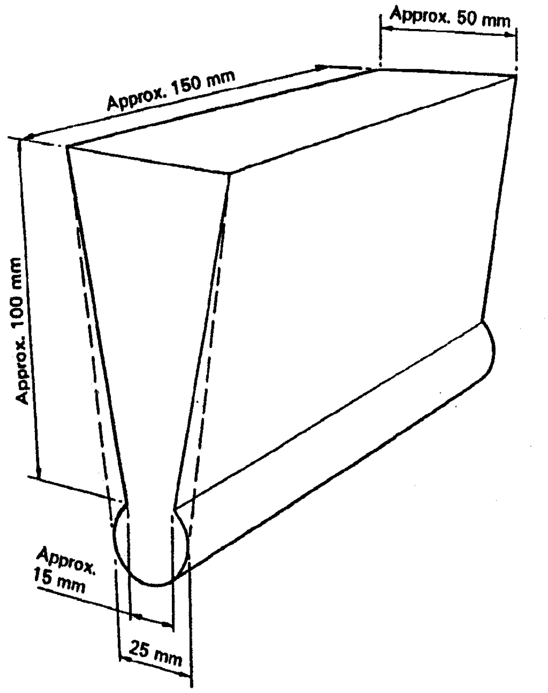


Fig. 3.6.1 : Keel block test sample

3.6.3 Where castings are supplied in the heat treated condition, the test samples are to be heat treated together with the castings which they represent.

3.6.4 The results of all tests are to comply with the appropriate requirements given in Table 3.6.1.

Note : These properties are a measure of the mechanical quality of the metal in each heat and they are generally not representative of the mechanical properties of the propeller casting itself which may be upto 30% lower than that of a separately cast test coupon. For integrally cast test specimens the requirements are to be specially agreed with IRS.

Table 3.6.1 : Mechanical properties for acceptance purposes : propeller and propeller blade castings

Alloy Designation	0.2% proof stress [N/mm^2] minimum	Tensile Strength [N/mm^2] minimum	Elongation on $5.65\sqrt{S_o}$% minimum
Grade Cu1 Manganese bronze	175	440	20
Grade Cu2 Ni-Manganese bronze	175	440	20
Grade Cu3 Ni-Aluminium bronze	245	590	16
Grade Cu4 Mn-Aluminium bronze	275	630	18

Note:

The mechanical properties of other alloys meeting the above limiting values are to be in accordance with a specification approved by IRS.

3.7 Surface quality and dimensions

3.7.1 All castings are to be fettled, cleaned and adequately prepared for inspection.

3.7.2 Propeller castings are to be inspected at all stages of manufacture and the whole surface including the bore is to be subjected to a comprehensive visual examination in the finished condition by the Surveyor. The Surveyor may require areas to be etched (e.g. by iron chloride) for purpose of investigating weld repairs.

3.7.3 The dimensions are to be checked by the manufacturer and the report on the dimensional inspection is to be given to the Surveyor, who may require checks to be made in his presence.

3.8 Non-destructive examination

3.8.1 Dye penetrant inspection

a) The severity zones "A" are to be subjected to a dye penetrant inspection in the presence of the Surveyor. For the inspection and acceptance standard, see 3.10. In zones "B" and "C" the dye penetrant inspection is to be performed by the manufacturer and may be witnessed by the Surveyor upon his request. See 3.9 for definitions of severity zones.

b) If repairs have been made either by grinding or by welding the repaired areas are additionally to be subjected to the dye penetrant inspection independent of their location and/or severity zone.

3.8.2 Radiographic and ultrasonic examination

Where serious doubts exist that the castings are not free from internal defects further non-destructive examination is to be carried out upon request of the Surveyor, e.g. radiographic and/or ultrasonic testing. Acceptance criteria are to be agreed between the manufacturer and IRS in accordance with a recognized standard.

Guidance

The absorption of the X-rays and gamma-rays is stronger in copper-based alloys than in steel. For propeller bronzes, 300 kV X-rays can normally be used upto 50 [mm] and Co60 gamma-rays upto 160 [mm] thickness. Due to the limited thicknesses that can be radiographed as well as for other practical reasons radiography is generally not a realistic method for checking of the thickest parts of large propellers.
As a general rule, ultrasonic testing of Cu1 and Cu2 is not feasible due to the high damping capacity of these materials. For Cu3 and Cu4, ultrasonic inspection of subsurface defects is possible.

3.8.3 Documentation of defects

All defects requiring welding repair on the castings are to be documented preferably on drawings or special sketches showing their dimensions and locations. Furthermore, the inspection procedure is to be documented. The documentation is to be presented to the Surveyor prior to any repair welding.

3.9 Definition of skew, severity zones

3.9.1 Skew : The skew of a propeller is defined as follows:

The maximum skew angle of a propeller blade is defined as the angle, in projected view of the blade, between a line drawn through the blade tip and the shaft centreline and a second line through the shaft centreline which acts as a tangent to the locus of the mid-points of the helical blade section. See Fig.3.9.1.

High skew propellers have a skew angle greater than 25°, low skew propellers a skew angle of up to 25°.

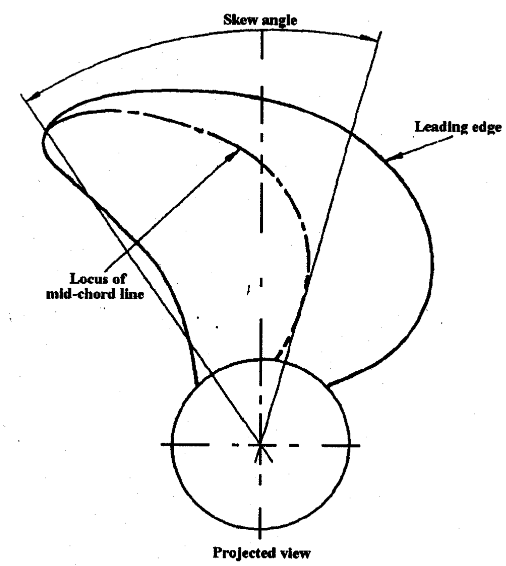


Fig.3.9.1 : Definition of skew angle

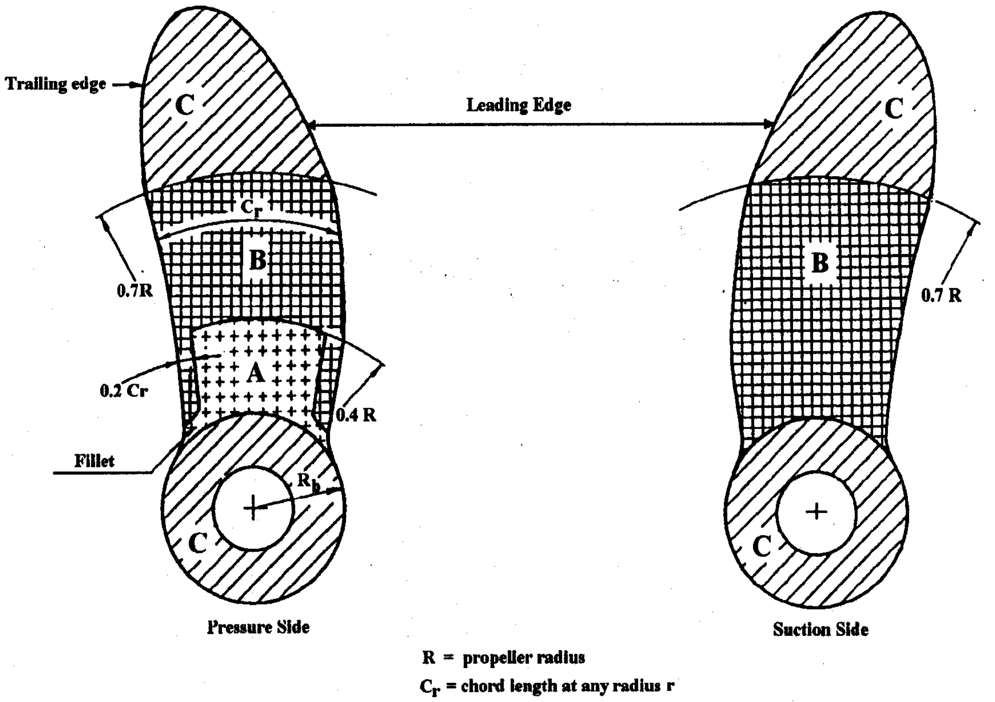


Fig. 3.9.2 : Severity zones for integrally cast low skew propellers

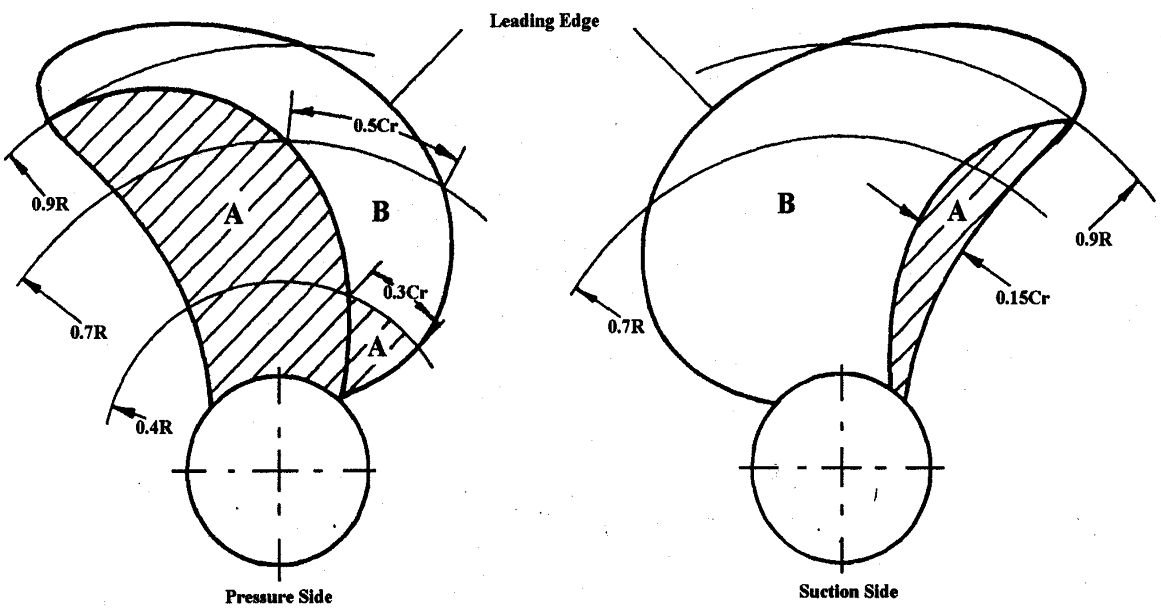


Fig. 3.9.3 : Severity zones in blades with skew angles greater than 25 degrees

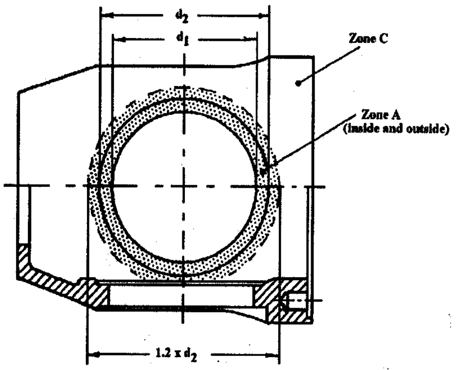


Fig. 3.9.4 : Severity zones for controllable pitch propeller boss

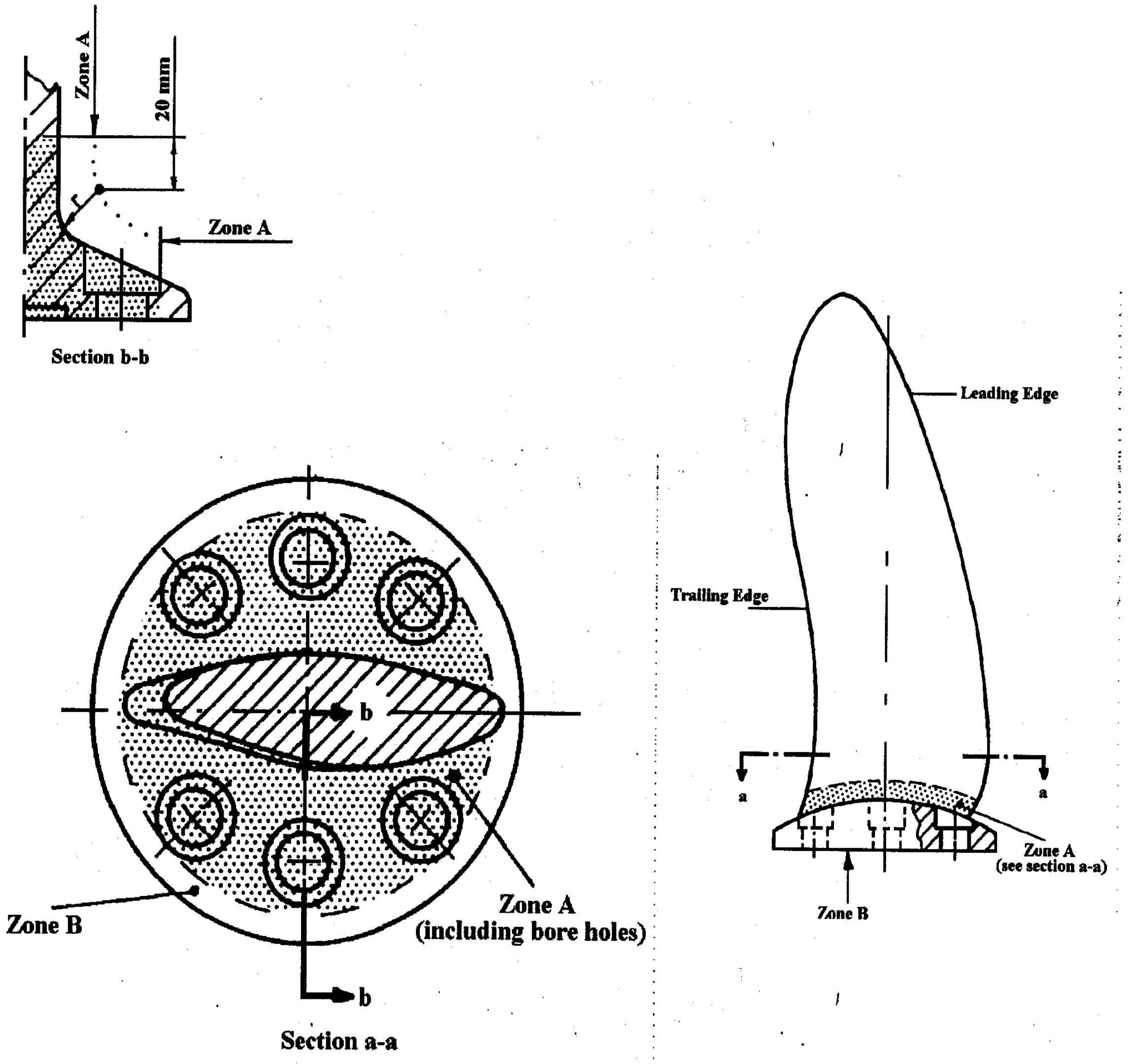


Fig. 3.9.5 : Severity zones for controllable and built-up propellers

[Note : The remaining surfaces of the propeller blades are to be divided into severity zones as given for solid propellers (Fig. 3.9.2 and 3.9.3)]

3.9.2 Severity zones

In order to relate the degree of examination to the criticality of defects in propeller blades and to help reduce the risk of failure by fatigue cracking after repair, propeller blades are divided into the three zones designated A, B and C.

Zone A is the region carrying the highest operating stresses and which, therefore, requires the highest degree of inspection. Generally, the blade thicknesses are greatest in this area giving the greatest degree of restraint in repair welds and this in turn leads to the highest residual stresses in and around any repair welds. High residual tensile stresses frequently lead to fatigue cracking during subsequent service so that relief of these stresses by heat treatment is essential for any welds made in this zone. Welding is generally not permitted in Zone A and will only be allowed after special consideration by the Classification Society. Every effort should be made to rectify a propeller which is either defective or damaged in this area without recourse to welding even to the extent of reducing the scantlings, if this is acceptable. If a repair using welding is agreed, post-weld stress relief heat treatment is mandatory.

Zone B is a region where the operation stresses may be high. Welding should preferably be avoided but generally is allowed subject to prior approval from the Classification Society. Complete details of the defect/damage and the intended repair procedure are to be submitted for each instance in order to obtain such approval.

Zone C is a region in which the operation stresses are low and where the blade thicknesses are relatively small so that repair welding is safer and, if made in accordance with an approved procedure is freely permitted.

3.9.2.1 Low-skew propellers

a) Zone A is in the area on the pressure side of the blade, from and including the fillet to 0.4R and bounded on either side by lines at a distance 0.15 times the chord length Cr from the leading edge and 0.2 times Cr from the trailing edge, respectively. See Fig.3.9.2.

   Where the hub radius (Rb) exceeds 0.27R, the other boundary of Zone A is to be increased to 1.5Rb. Zone A also includes the parts of the separate cast propeller hub which lie in the area of the windows as described in Fig.3.9.4 and the flange and fillet area of controllable pitch and built-up propeller blades as described in Fig.3.9.5.

b) Zone B is on the pressure side the remaining area upto 0.7R and on the suction side the area from the fillet to 0.7R. See Fig.3.9.1.

c) Zone C is the area outside 0.7R on both sides of the blade. It also includes the surface of the hub of a monobloc propeller and all the surfaces of the hub of controllable pitch propeller other than those designated Zone A above.

3.9.2.2 High-skew propellers

a) Zone A is the area on the pressure face contained within the blade root-fillet and a line running from the junction of the leading edge with the root fillet to the trailing edge at 0.9R and at passing through the mid-point of the blade chord at 0.7R and a point situated at 0.3 of the chord length from the leading edge at 0.4R. It also includes an area along the trailing edge on the suction side of the blade from the root to 0.9R and with its inner boundary at 0.15 of the chord lengths from the trailing edge.

b) Zone B constitutes the whole of the remaining blade surfaces.

c) Zone A and B are illustrated in Fig.3.9.3.

3.10 Acceptance criteria for dye penetrant examination

3.10.1 Inspection procedure

The dye penetrant inspection is to be carried out in accordance with a standard or specification agreed with the Surveyor.

3.10.2 Definitions

Indication — In the dye penetrant inspection an indication is the presence of detectable bleed-out of the penetrant liquid from the material discontinuities appearing at least 10 minutes after the developer has been applied.

Shape of Indications — A distinction is made between circular, linear and aligned indications, See Fig.3.10.1.

Reference area — The reference area is defined as an area of 100 [cm^2] which may be square or rectangular with the major dimension not exceeding 250 [mm].

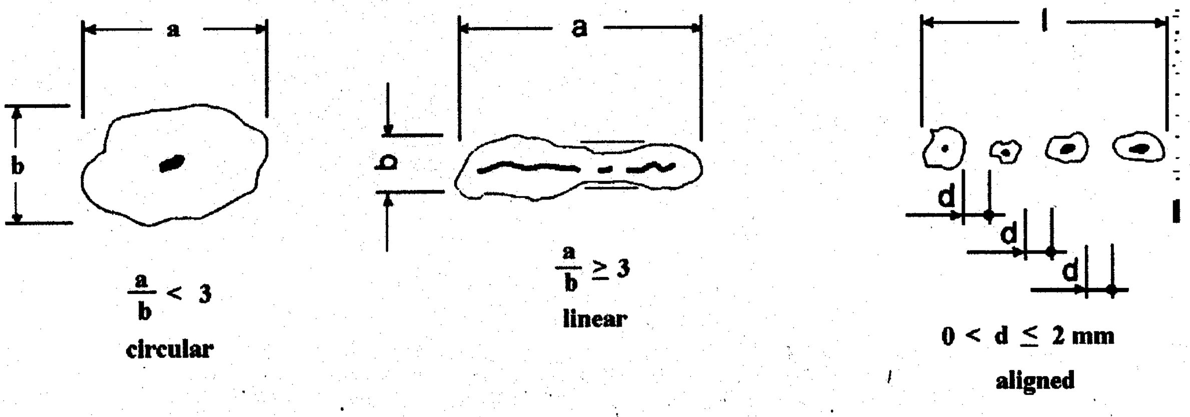


Fig.3.10.1 : Shape of indications

Table 3.10.1 : Allowable number and size of indications in a reference area of 100 [cm^2], depending on severity zones

Severity zones	Max. total number of indications	Type of indication	Max. number of each type [1)2)]	Max. acceptable value for "a" or "l" of indications [mm]
A	7	Circular Linear Aligned	5 2 2	4 3 3
B	14	Circular Linear Aligned	10 4 4	6 6 6
C	20	Circular Linear Aligned	14 6 6	8 6 6

Notes:

1) Singular circular indications less than 2 [mm] for zone A and less than 3 [mm] for the other zones may be disregarded.

2) The total number of circular indications may be increased to the max. total number, or part thereof, represented by the absence of linear/aligned indications.

3.10.3 Acceptance standard

3.10.3.1 For the judgement, the surface to be inspected is to be divided into reference areas of 100 [cm^2] as given in the definitions, see para 3.10.2. The indications detected may, with respect to their size and number, not exceed the values given in the Table 3.10.1.

The area is to be taken in the most unfavourable location relative to the indication being evaluated.

3.10.3.2 Areas which are prepared for welding are, independent of their location, always to be assessed according to Zone A. The same applies to the welded areas after being finished machined and/or ground.

3.11 Metallographic examination

3.11.1 Samples for metallographic examination are to be prepared from propellers and propeller blade castings for Grades Cu1 and Cu2. These samples are to be representative of each cast, and may conveniently be taken from the tensile test specimen. The proportion of alpha-phase determined from the average of at least five counts is to be not less than 25 percent.

3.12 Rectification of defects

3.12.1 Indications exceeding the acceptance standard of Table 3.10.1, cracks, shrinkage cavities, sand, slag and other non-metallic inclusions, blow holes and other discontinuities which may impair the safe service of the propeller are defined as defects and must be repaired.

3.12.2 Repair procedures

a) In general the repairs are to be carried out by mechanical means, e.g. by grinding, chipping or milling. Welding may be applied subject to the agreement with the Surveyor.

b) After milling or chipping grinding is to be applied for such defects which are not to be welded. Grinding is to be carried out in such a manner that the contour of the ground depression is as smooth as possible in order to avoid stress concentrations or to minimise cavitation corrosion.

c) Welding of areas less than 5 [cm^2] is to be avoided.

3.12.3 Repair of defects in zone A

a) In zone A, repair welding will generally not be allowed unless specially approved by IRS.

b) Grinding may be carried out to an extent which maintains the blade thickness of the approved drawing.

c) The possible repair of defects which are deeper than those referred to above will be specially considered by IRS.

3.12.4 Repair of defects in zone B

a) Defects that are not deeper than dB = (t/40) [mm] (t = minimum local rule thickness [mm]) or 2 [mm] (whichever is greater) below minimum local rule thickness should be removed by grinding.

b) Those defects that are deeper than allowable for removal by grinding may be repaired by welding.

3.12.5 Repair of defects in zone C

In zone C, repair welds are generally permitted.

3.13 Balancing

3.13.1 Static balancing is to be carried out on all propellers. Dynamic balancing is necessary for propellers running above 500 [rpm].

3.14 Repair welding

3.14.1 General requirements

3.14.1.1 Companies wishing to carry out welding work on propellers must have at their disposal the necessary workshops, lifting gear, welding equipment, preheating and where necessary, annealing facilities, testing devices as well as certified welders and expert welding supervisors to enable them to perform the work properly. Proof is to be furnished to the Surveyor that these conditions are satisfied before welding work begins.

3.14.1.2 The company concerned is to prepare and submit to IRS a detailed welding specification covering the weld preparation, welding procedure, filler metals, preheating and post weld heat treatment and inspection procedures.

3.14.1.3 Before welding is started, Welding Procedure Qualification Tests are to be carried out and witnessed by the Surveyors. Each welder/operator is to demonstrate his ability to carry out the proposed welding using the same process, consumable and position which are to be used in actual repair (for the scope of tests see 3.18).

3.14.2 Welding preparation

Defects to be repaired by welding are to be ground to sound material according to the requirements as given under 3.12. To ensure complete removal of the defects the ground areas are to be examined by dye penetrant methods in the presence of the Surveyor. The welding grooves are to be prepared in such a manner which will allow a good fusion of the groove bottom.

3.14.3 Welding repair procedure

3.14.3.1 Metal arc welding is recommended for all types of repair on bronze propellers.

For material thickness less than 30 [mm], gas welding may give a satisfactory weldment for Cu1 and Cu2 materials.

Arc welding with coated electrodes and gas-shielded metal arc process (GMAW) are generally to be applied. Argon-shielded tungsten welding (GTAW) is to be used with care due to the higher specific heat input of this process.

Adequate pre-heating is to be carried out with care to avoid local overheating.

Recommended filler metals, pre-heating and stress relieving temperatures are listed in Table 3.14.3(a).

3.14.3.2 All propeller alloys are generally to be welded in down-hand (flat) position. Where this cannot be done, gas-shielded metal arc welding is to be carried out.

The section to be welded is to be clean and dry. Flux-coated electrodes are to be dried before welding according to the maker's instructions.

To minimize distortion and the risk of cracking, interpass temperatures are to be kept low especially in the case of Cu3 alloys.

Slag, undercuts and other defects are to be removed before depositing the next run.

Table 3.14.3(a) : Recommended filler metals and heat treatments

Alloy type	Filler metal	Preheat temp.°C [min]	Interpass temp.°C [max]	Stress relief temp.°C	Hot straightening temp.°C
Cu1	Al-bronze [1)] Mn-bronze	150	300	350 - 500	500 - 800
Cu2	Al-bronze Ni-Mn-bronze	150	300	350 - 550	500 - 800
Cu3	Al-bronze Ni-Al-bronze [2)] Mn-Al-bronze	50	250	450 - 500	700 - 900
Cu4	Mn-Al-bronze	100	300	450 - 600	700 - 850

Notes:

1) Ni-Al-bronze and Mn-Al-bronze are acceptable.

2) Stress relieving not required, if filler metal Ni-Al-bronze is used.

Table 3.14.3(b) : Soaking times for stress relief heat treatment of copper alloy propellers				
Stress relief temp.°C	**Alloy grade Cu1 and Cu2**		**Alloy grade Cu3 and Cu4**	
	Hours per 25 [mm] thickness	**Max. recommended total time hours**	**Hours per 25 [mm] thickness**	**Max. recommended total time hours**
350	5	15	-	-
400	1	5	-	-
450	1/2	2	5	15
500	1/4	1	1	5
550	1/4	1.2	1/2 [1)]	2 [1)]
600	-	-	1/4 [1)]	1 [1)]
Note 1) 550°C and 600°C only applicable for Cu4 alloys				

3.14.3.3 All welding work is to be carried out preferably in the shop free from draughts and influence of the weather.

3.14.3.4 With the exception of alloy Cu3 (Ni-Al-bronze) all weld repairs are to be stress relief heat treated, in order to avoid stress corrosion cracking. However, stress relief heat treatment of alloy Cu3 propeller castings may be required after major repairs in zone B (and specially approved welding in Zone A) or if a welding consumable susceptible to stress corrosion cracking is used. In such cases the propeller is to be either stress relief heat treated in the temperature 450 to 500°C or annealed in the temperature range 650 - 800°C, depending on the extent of repair, see Table 3.14.3(a).

3.14.3.5 The soaking times for stress relief heat treatment of copper alloy propellers is to be in accordance with Table 3.14.3(b). The heating and cooling is to be carried out slowly under controlled conditions. The cooling rate after any stress relieving heat treatment shall not exceed 50°C/hr until the temperature of 200°C is reached.

3.15 Straightening

3.15.1 Application of load

For hot and cold straightening purposes, static loading only is to be used.

3.15.2 Hot straightening

Straightening of a bent propeller blade or a pitch modification should be carried out after heating the bent region and approximately 500 [mm] wide zones on either side of it to the suggested temperature range given in Table 3.14.3.(a). The heating is to be slow and uniform and the concentrated flames such as oxy-acetylene and oxy-propane are not to be used. Sufficient time is be allowed for the temperature to become fairly uniform through the full thickness of the blade section. The temperature is to be maintained within the suggested range throughout the straightening operation. A thermocouple instrument or temperature indicating crayons are to be used for measuring the temperature.

3.15.3 Cold straightening

Cold straightening should be used for minor repairs of tips and edges only. Cold straightening on Cu1, Cu2 and Cu4 bronze is always to be followed by a stress relieving heat treatment, See Table 3.14.3(a).

3.16 Identification

3.16.1 Castings are to be clearly marked by the manufacturer in accordance with the requirements of Ch.1. The following details are to be marked on all the castings which have been accepted:

a) Heat number, casting number or other identification mark which will enable the full history of the item to be traced;

b) Alloy grade;

c) IR and the abbreviated name of the local IRS office;

d) Personal stamp of the Surveyor responsible for inspection;

e) Date of final inspection;

f) IRS certificate number;

g) Skew angle for high skew propellers;

h) Ice class symbol, where applicable.

3.17 Certification

3.17.1 The manufacturer is to provide the Surveyor with a written statement giving the following particulars for each casting:

a) Purchaser's name and order number;

b) Description of casting;

c) Alloy designation and/or trade name;

d) Identification number of casting;

e) Type of heat treatment.

3.18 Welding procedure and welder's qualification test

3.18.1 General

The qualification test is to be carried out with the same welding process, filler metal, preheating and stress-relieving treatment as those intended to be applied in the actual repair work.

3.18.2 Test sample

A test sample of minimum 30 [mm] thickness is to be welded in down-hand (flat) position. The required test specimens and their dimensions are shown in Fig.3.18.1.

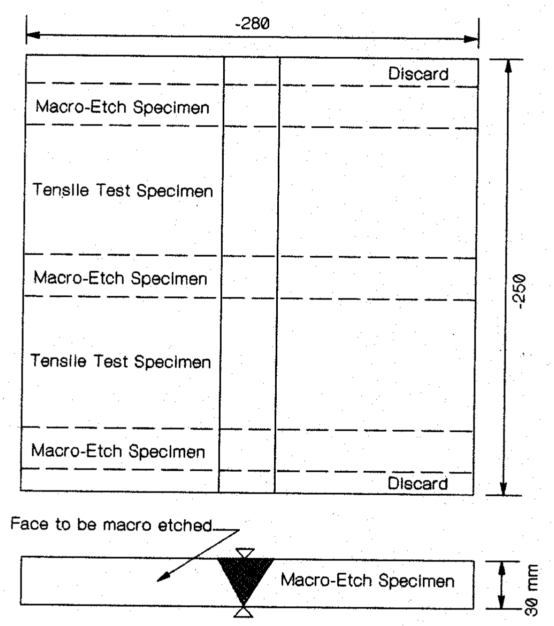


Fig.3.18.1 : Test specimen

3.18.3 Qualification testing

3.18.3.1 Non-destructive testing

After completion, the weldment is to be 100% tested by a dye-penetrant method. No cracks are permitted.

3.18.3.2 Macro-etching

Three macro-etch samples are to be prepared (See Fig.3.18.1). A suitable etchant for this purpose is:

5 g iron (III) chloride
30 ml hydrochloric acid (cone)
100 ml water.

Pores greater than 3 [mm] and cracks are not permitted.

3.18.3.3 Mechanical testing

Two tensile test specimens are to be prepared as given in 1.8.2 and Fig.1.8.2 of Part 2, Chapter 11 The tensile strength requirements given in Table 3.18.3, are to be met. Alternatively tensile test specimens according to recognised standards may be used.

Table 3.18.3 : Required tensile strength values

Alloy Type	Tensile strength [N/mm^2] min
Cu 1	370
Cu 2	410
Cu 3	500
Cu 4	550

Section 4

Tubes

4.1 Scope

4.1.1 Following requirements make provision for copper and copper alloy tubes intended for use in heat exchangers, condensers and pressure piping systems.

4.1.2 Except for pipes for Class lll pressure systems (as defined in Pt.4, Ch.2) all pipes and tubes are to be manufactured and tested in accordance with the requirements of Ch.1 and 2 of this Part and the requirements of this Section.

4.1.3 Pipes and tubes which comply with national/international or proprietary specifica-ions may be accepted provided that these specifications give reasonable equivalence to the requirements of this Section or are otherwise specifically approved for a specific application and provided that survey is carried out in accordance with Ch.1 of this Part.

4.1.4 At the discretion of the Surveyor, modified testing procedure may be adopted for small quantities of materials. In such cases, these may be accepted on the manufacturer's declared chemical composition and hardness tests or other evidence of satisfactory properties.

4.1.5 Pipes for Class lll pressure systems are to be manufactured and tested in accordance with the requirements of an acceptable national/ international specification. The manufacturer's test certificate will be acceptable and is to be provided for each consignment of material.

4.2 Manufacture

4.2.1 Approval of Works, as required by Ch.1, for the manufacture of copper and copper alloy tubes is generally not required.

4.2.2 Unless otherwise agreed tubes shall be solid drawn.

4.3 Quality

4.3.1 Tubes are to have a workmanlike finish and are to be clean and free from such surface and internal defects as can be established by the specified tests.

4.3.2 The tubes are to be supplied in straight lengths, and the ends are to be cut clean and square with the axis of the tube.

4.3.3 The tolerance on wall thickness and diameter of pipes and tubes are to be in accordance with an acceptable national/ international standard.

4.4 Chemical composition

4.4.1 The chemical analysis is to comply with the requirements of Table 4.4.1. Residual elements are not to be present in amounts greater than specified in an acceptable national/international standard.

4.5 Heat treatment

4.5.1 All tubes are to be supplied in the annealed condition. Aluminium brass tubes may additionally be required to be given a suitable stress relieving heat treatment when subjected to a cold straightening operation after annealing.

4.6 Mechanical tests

4.6.1 The tubes are to be presented in lots of 600 tubes or 900 [Kg], whichever is greater. Each lot is to contain tubes of the same dimensions, material grade and in the same state of heat treatment. From each lot 2 tubes are to be selected for testing.

4.6.2 Following tests are to be carried out on each tube selected for testing in accordance with the requirements of Ch.2:

a) Tensile test;

b) Flattening test;

c) Drift Expanding test.

4.6.3 Flattening test is to be carried out until the interior surfaces of the tube meet.

4.6.4 For the drift-expanding test, the mandrel is to have an included angle of 45°.

4.6.5 The results of all mechanical tests are to comply with the requirements of Table 4.6.1.

Table 4.4.1 : Chemical composition of tubes [1)]

Designation	Chemical composition %								
	Cu	**Fe**	**Ni**	**Zn**	**As**	**Al**	**Mn**	**P**	**Pb**
Phosphorus deoxidised non-arsenical copper	99.90 [2)] min.	-	-	-	-	-	-	0.013-0.050	-
Phosphorus deoxidised arsenical copper	99.20 [2)] min.	-	-	-	0.30-0.50	-	0.013-0.050	-	-
Al-brass	76.0-79.0	-	-	Remainder	0.02-0.06	1.8-2.3	-	-	-
Copper-nickel 90/10	Remainder	1.0-1.8	9.0-11.0	-	-	-	0.5-1.0	-	-
Copper-nickel 70/30	Remainder	0.4-1.0	30.0-32.0	-	-	-	0.5-1.5	-	-

Notes:

1) Table shows essential alloying elements only
2) Includes silver also.

4.7 Visual examination

4.7.1 All pipes are to be presented for visual examination and verification of dimensions. The manufacturer is to provide adequate lighting conditions to enable an internal and external examination of the tubes to be carried out.

4.8 Stress cracking test

4.8.1 This test is applicable to aluminium brass only. Mercurous Nitrate Test or alternatively at the express agreement between purchaser and manufacturer Ammonia Vapour Cracking Test are to be carried out on test specimen to prove that the tubes are free from internal stresses. The tests are to be carried out in accordance with an acceptable national/international standard.

4.8.2 Should a specimen reveal cracks when tested, the manufacturing batch shall be rejected. The manufacturer shall be free to submit the batch to renewed heat treatment before presenting it for retesting.

4.9 Hydraulic test

4.9.1 All tubes are to be hydraulically tested by the manufacturer to the following pressure:

$$P = \frac{5 \text{ x } t \text{ x } Rm}{D}$$

where,

P = Test pressure;

t = nominal wall thickness;

D = nominal outside diameter;

Rm = Tensile strength in accordance with Table 4.6.1.

Unless otherwise stated the pressure need not be greater than 7.0 [N/mm^2].

4.9.2 The test pressure is to be maintained for sufficient time to permit proof and inspection. Unless otherwise agreed, the manufacturer's certificate of satisfactory hydraulic test will be accepted subject to 10 per cent of the tubes being retested in the presence of the Surveyor. If one of the tubes in a batch does not pass the test, it will be rejected, and all other tubes in the batch are to be retested.

4.10 Identification

4.10.1 Tubes are to be clearly marked by the manufacturer in accordance with the requirements of Ch.1, with at least the following details:

a) IR;

b) Manufacturer's name or trade mark;

c) Grade of material.

4.10.2 Identification is to be by rubber stamp or stencil. Hard stamping is not to be used.

4.11 Certification

4.11.1 The manufacturer is to provide the Surveyor with a written statement giving the following particulars for each lot of material accepted:-

a) Purchaser's name and Order no.;

b) Grade of material;

c) Description and dimensions;

d) Cast number and chemical composition;

e) Mechanical test results and results of stress cracking tests where applicable.

Table 4.6.1 : Mechanical properties for acceptance purposes

Designation	0.2% proof stress [N/mm^2] minimum	Tensile strength [N/mm^2] minimum	$5.65\sqrt{S_o}$% minimum	Drift expansion test % minimum
Phosphorus deoxidised non-arsenical copper	100	220	35	30
Phosphorus deoxidised arsenical copper	100	220	35	30
Al-brass	110	320	35	30
Copper-nickel 90/10	100	270	30	30
Copper-nickel 70/30	120	360	30	30

End of Chapter

Chapter 9

Aluminium Alloys

Contents

Section

Section 1

General

1.1 Scope

1.1.1 This Chapter specifies the requirements for wrought aluminium alloys for structural applications, aluminium alloy castings and aluminium/steel transition joints intended for use in ship and machinery construction.

1.1.2 This Chapter is not applicable to aluminium alloys for forgings and to the use of aluminium alloys at low temperature for cryogenic applications. For these products suitable alloys which comply with recognized standards may be used.

1.1.3 These requirements are applicable to wrought aluminium alloy products within a thickness range of 3 [mm] and 50 [mm] inclusive. The application of aluminium alloys products outside this thickness range requires prior agreement of IRS.

1.1.4 The numerical designation (grade) of aluminium alloys and the temper designation are based on those of the Aluminium Association.

Temper conditions (delivery heat treatment) are as defined in EN 515 Or ANSI H35.1.

1.1.5 When required by the relevant Chapters of the Rules dealing with design and construction, structural aluminium alloys, aluminium alloy castings and aluminium/steel transition joints are to be manufactured and tested in accordance with the appropriate requirements of Ch.1 and 2 and those detailed in this Chapter.

1.1.6 Consideration may be given to aluminium alloys not specified in this chapter and to alternative temper conditions, complying with recognized national or international standards with specifications equivalent to the requirements of this chapter.

Section 2

Wrought Aluminium Alloys

2.1 Scope

2.1.1 This Section deals with wrought aluminium alloys for structural applications including plates, sections, tubes, bars and rivet bars and rivets.

2.1.2 Wrought aluminium alloys are to have a satisfactory resistance to corrosion in marine environment. Grades for welded structures are to be weldable, applying one of the welding methods approved by IRS.

2.1.3 The alloy grades 6005A, 6061 of the 6000 series should not be used in direct contact with sea water unless protected by anodes and/or paint system.

2.2 Manufacture

2.2.1 Aluminium alloys are to be manufactured at Works approved by IRS.

2.2.2 The alloys may be cast either in ingot moulds or by an approved continuous casting process. Plates are to be formed by rolling and may be hot or cold finished. Bars and sections may be formed by rolling, extrusion or drawing.

2.3 Quality of materials

2.3.1 Materials are to be free from surface or internal defects of such a nature as would be harmful in service.

2.4 Dimensional tolerances

2.4.1 The dimensional tolerances are to be in accordance with Table 2.4.1, Table 2.4.2 and Table 2.4.3 and are minimum requirements.

2.4.2 Dimensional tolerances other than those given in Table 2.4.1, Table 2.4.2 and Table 2.4.3 are to comply with a recognized national or international standard.

2.5 Chemical composition

2.5.1 Samples for chemical analysis are to be taken representative of each cast, or the equivalent where a continuous melting process is involved.

2.5.2 The chemical composition of these samples is to comply with the requirements of Table 2.5.1.

Table 2.4.1 : Under thicknesses tolerances for rolled products

	Thickness tolerances for nominal width [mm]		
Nominal thickness [t] [mm]	w ≤ 1500	1500 < w ≤ 2000	2000 < w ≤ 3500
3.0 ≤ t < 4.0	0.10	0.15	0.15
4.0 ≤ t < 8.0	0.20	0.20	0.25
8.0 ≤ t < 12.0	0.25	0.25	0.25
12.0 ≤ t < 20.0	0.35	0.40	0.50
20.0 ≤ t < 50.0	0.45	0.50	0.65

Table 2.4.2 : Under thicknesses tolerances for extruded open profiles

	Thickness tolerances for nominal thicknesses for a diameter of the circumscribing circle [mm]		
Nominal thickness [mm]	Upto 250	From 250 to 400	Above 400
From 3 to 6	0.25	0.35	0.40
From 6 to 50	0.30	0.40	0.45

Table 2.4.3 : Under thicknesses tolerances for extruded closed profiles

Nominal thickness [mm]	Thickness tolerances [mm]
From 3 to 6	0.25
From 6 to 50	0.30

Table 2.5.1 : Chemical composition

Grade	Al	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Oth-ers (2)	Oth-ers (2)	Misc.
	%	%	%	%	%	%	%	%	%	Each %	Total %	
5059	Remainder	0.45	0.50	0.25	0.6-1.2	5.0-6.0	0.25	0.40-0.90	0.20	0.05 [3)]	0.15 [4)]	
5083	Remainder	≤ 0.40	≤ 0.40	≤ 0.10	0.4-1.0	4.0-4.9	0.05-0.25	≤ 0.25	≤ 0.15	≤ 0.05	≤ 0.15	
5086	Remainder	≤ 0.40	≤ 0.50	≤ 0.10	0.20-0.7	3.5-4.5	0.05-0.25	≤ 0.25	≤ 0.15	≤ 0.05	≤ 0.15	
5383	Remainder	0.25	0.25	0.20	0.7-1.0	4.0-5.2	0.25	0.40	0.15	0.05 [3)]	0.15 [3)]	
5754	Remainder	≤ 0.40	≤ 0.40	≤ 0.10	≤ 0.50	2.6-3.6	≤ 0.30	≤ 0.20	≤ 0.15	≤ 0.05	≤ 0.15	0.10 ≤ Mn + Cr ≤ 0.60
5456	Remainder	0.25	0.40	0.10	0.50 – 1.0	4.7 – 5.5	0.05 – 0.20	0.25	0.20	0.05	0.15	
6005-A	Remainder	0.50-0.9	≤ 0.35	≤ 0.30	≤ 0.50	0.040-0.7	≤ 0.30	≤ 0.20	≤ 0.10	≤ 0.05	≤ 0.15	0.12 ≤ Mn + Cr ≤ 0.50
6061	Remainder	0.40-0.8	≤ 0.7	0.15-0.40	≤ 0.15	0.8-1.2	0.04-0.35	≤ 0.25	≤ 0.15	≤ 0.05	≤ 0.15	
6082	Remainder	0.7-1.3	≤ 0.50	≤ 0.10	0.40-1.0	0.6-1.2	≤ 0.25	≤ 0.20	≤ 0.10	≤ 0.05	≤ 0.15	

Notes:

1. Slight variations in the content of some elements, compared with values indicated in this Table may be accepted with IRS's agreement.
2. Other metallic elements such as Ni, Ga.V are considered as impurities. The regular analysis need not be made for these elements.
3. Zr: maximum 0.20. The total for other elements does not include Zirconium.
4. Zr: 0.05-0.25. The total for other elements does not include Zirconium.

2.5.3 The manufacturer's declared analysis will be accepted subject to occasional checks if required by IRS Surveyor, particularly, product analysis may be required where the final product chemistry is not well represented by the analysis from the cast.

2.5.4 When the aluminium alloys are not cast in the same works in which they are manufactured into semi finished products, the works is to give a certificate detailing the chemical composition and heat number.

2.6 Heat treatment

2.6.1 Temper conditions (delivery heat treatment) are defined in Table 2.8.1.

2.7 Test material

2.7.1 All materials in a lot forwarded for sampling are to be of the same alloy, production batch and product form (plates, sections etc.). The materials in one lot are to be of the same dimensions and in the same delivery condition.

Artificially aged grades are to be from the same furnace batch.

2.7.2 Wherever practicable, the tensile test pieces for rolled and extruded sections are to be of full section of material. Otherwise, the pieces are to be taken in the range one third to half the distance from the edge to center of the predominant or thickest part of the section.

2.8 Testing and inspection

2.8.1 Testing procedures

The test specimens and procedures are to be in accordance with Ch.2.

2.8.2 Verification of proper fusion of press welds for closed profiles.

The Manufacturer has to demonstrate by macrosection tests or drift expansion tests of closed profiles performed on each batch of closed profiles that there is no lack of fusion at the press welds.

2.8.3 Drift expansion tests

2.8.3.1 Every fifth profile is to be sampled after final heat treatment.
One sample is to be selected from the batches of five profiles or less.

Every profile is to be selected if the length exceeds 6 [m].

2.8.3.2 Two samples are to be cut from the front and back end of each production profile.

2.8.3.3 The test specimens are to be cut with the ends perpendicular to the axis of the profile. The edges of the end may be rounded by filing.

2.8.3.4 The length of the specimen is to be in accordance with details given in Chapter 2.

2.8.3.5 Testing is to be carried out at ambient temperature and is to consist of expanding the end of the profile by means of a hardened conical steel mandrel having an included angle of at least 60°.

2.8.3.6 The sample is considered to be unacceptable if the sample fails with a clean split along the weld line which confirms lack of fusion.

2.8.4 Requirements of mechanical properties for rolled products in different delivery conditions are given in Table 2.8.1 and are applicable for thickness within the range 3 [mm] to 50 [mm]. For thickness above 10 [mm], however, lower mechanical properties may be accepted.

2.8.5 Requirements of mechanical properties for extruded products in different delivery conditions are given in Table 2.8.2 and are applicable for thickness within the range 3 [mm] to 50 [mm].

2.8.6 Requirements of mechanical properties and delivery conditions for extruded closed profiles are given in Table 2.8.3.

2.8.7 Other delivery conditions with related mechanical properties may be accepted by IRS, in each particular case.

<table>
<tr><th colspan="7">Table 2.8.1 : Mechanical properties for rolled products 3 [mm] ≤ t ≤ 50 [mm]</th></tr>
<tr><th rowspan="2">Grade</th><th rowspan="2">Temper [3] condition</th><th rowspan="2">Thickness, [t]</th><th rowspan="2">0.2% proof stress [N/mm^2]</th><th rowspan="2">Tensile strength [N/mm^2]</th><th colspan="2">Elongation % minimum [1]</th></tr>
<tr><th>On gauge length of 50 [mm]</th><th>On gauge length of 5 x dia</th></tr>
<tr><td rowspan="5">5083</td><td>O</td><td>3 ≤ t ≤ 50 mm</td><td>125</td><td>275-350</td><td>16</td><td>14</td></tr>
<tr><td>H111</td><td>3 ≤ t ≤ 50 mm</td><td>125</td><td>275-350</td><td>16</td><td>14</td></tr>
<tr><td>H112</td><td>3 ≤ t ≤ 50 mm</td><td>125</td><td>275</td><td>12</td><td>10</td></tr>
<tr><td>H116</td><td>3 ≤ t ≤ 50 mm</td><td>215</td><td>305</td><td>10</td><td>10</td></tr>
<tr><td>H321</td><td>3 ≤ t ≤ 50 mm</td><td>215-295</td><td>305-385</td><td>12</td><td>10</td></tr>
<tr><td rowspan="4">5383</td><td>O</td><td>3 ≤ t ≤ 50 mm</td><td>145</td><td>290</td><td>-</td><td>17</td></tr>
<tr><td>H111</td><td>3 ≤ t ≤ 50 mm</td><td>145</td><td>290</td><td>-</td><td>17</td></tr>
<tr><td>H116</td><td>3 ≤ t ≤ 50 mm</td><td>220</td><td>305</td><td>10</td><td>10</td></tr>
<tr><td>H321</td><td>3 ≤ t ≤ 50 mm</td><td>220</td><td>305</td><td>10</td><td>10</td></tr>
<tr><td rowspan="6">5059</td><td>O</td><td>3 ≤ t ≤ 50 mm</td><td>160</td><td>330</td><td>24</td><td>24</td></tr>
<tr><td>H111</td><td>3 ≤ t ≤ 50 mm</td><td>160</td><td>330</td><td>24</td><td>24</td></tr>
<tr><td rowspan="2">H116</td><td>3 ≤ t ≤ 20 mm</td><td>270</td><td>370</td><td>10</td><td>10</td></tr>
<tr><td>20 < t ≤ 50 mm</td><td>260</td><td>360</td><td>-</td><td>10</td></tr>
<tr><td rowspan="2">H321</td><td>3 ≤ t ≤ 20 mm</td><td>270</td><td>370</td><td>10</td><td>10</td></tr>
<tr><td>20 < t ≤ 50 mm</td><td>260</td><td>360</td><td>-</td><td>10</td></tr>
<tr><td rowspan="5">5086</td><td>O</td><td>3 ≤ t ≤ 50 mm</td><td>95</td><td>240-305</td><td>16</td><td>14</td></tr>
<tr><td>H111</td><td>3 ≤ t ≤ 50 mm</td><td>95</td><td>240-305</td><td>16</td><td>14</td></tr>
<tr><td rowspan="2">H112</td><td>3 ≤ t ≤ 12.5 mm</td><td>125</td><td>250</td><td>8</td><td></td></tr>
<tr><td>12.5 < t ≤ 50 mm</td><td>105</td><td>240</td><td></td><td>9</td></tr>
<tr><td>H116</td><td>3 ≤ t ≤ 50 mm</td><td>195</td><td>275</td><td>10 [2]</td><td>9</td></tr>
<tr><td rowspan="2">5754</td><td>O</td><td>3 ≤ t ≤ 50 mm</td><td>80</td><td>190-240</td><td>18</td><td>17</td></tr>
<tr><td>H111</td><td>3 ≤ t ≤ 50 mm</td><td>80</td><td>190-240</td><td>18</td><td>17</td></tr>
</table>

Table 2.8.1 : (Contd.)

Grade	**Temper [3] condition**	**Thickness, t**	**0.2% proof stress [N/mm^2]**	**Tensile strength [N/mm^2]**	**Elongation % minimum [1]**	
					On gauge length of 50 [mm]	**On gauge length of 5 x dia**
5456	O	$3 \leq t \leq 6.3$ mm	130-205	290-365	16	
		$6.3 < t \leq 50$ mm	125-205	285-360	16	14
	H116	$3 \leq t \leq 30$ mm	230	315	10	10
		$30 < t \leq 40$ mm	215	305		10
		$40 < t \leq 50$ mm	200	285		10
	H321	$3 \leq t \leq 12.5$ mm	230-315	315-405	12	
		$12.5 < t \leq 40$ mm	215-305	305-385		10
		$40 < t \leq 50$ mm	200-295	285-370		10

Notes:

1) Elongation in 50 mm apply for thicknesses upto and including 12.5 mm and in 5d for thicknesses over 12.5 mm.
2) 8% for thicknesses upto and including 6.3 mm.
3) The mechanical properties for the O and H111 tempers are the same. However, they are separated to discourage dual certification as these tempers represent different processing.

Designation	**Condition**
F	As fabricated
O	Annealed, soft
H1	Strain hardened only
H2	Strain hardened and partially annealed
H3	Strain hardened and thermally stabilized
H321	Strain hardened and stabilized
H11	Strain hardened to specified strength
H12	Strain hardened to specified strength
H13	Strain hardened to specified strength
H111	Less strain hardened than H11 e.g. by straightening or stretching
H112	No controlled strain hardening, but there are mechanical property limits
H116	Treatment against exfoliation corrosion
T5	Cooled from an elevated temperature shaping process and then artificially aged
T6	Solution heat treated and then artificially aged.

Table 2.8.2 : Mechanical properties for extruded products 3 [mm] ≤ t ≤ 50 mm

Grade	Temper condition	Thickness, t	0.2% proof stress [N/mm^2]	Tensile strength [N/mm^2]	Elongation % minimum [1)]	
					On gauge length of 50 [mm]	On gauge length of 5 x dia
5083	O	3 ≤ t ≤ 50 mm	110	270-350	14	12
	H/111	3 ≤ t ≤ 50 mm	165	275	12	10
	H112	3 ≤ t ≤ 50 mm	110	270	12	10
5383	O	3 ≤ t ≤ 50 mm	145	290	17	17
	H111	3 ≤ t ≤ 50 mm	145	290	17	17
	H112	3 ≤ t ≤ 50 mm	190	310		13
5059	H112	3 ≤ t ≤ 50 mm	200	330		10
5086	O	3 ≤ t ≤ 50 mm	95	240-315	14	12
	H111	3 ≤ t ≤ 50 mm	145	250	12	10
	H112	3 ≤ t ≤ 50 mm	95	240	12	10
6005A	T5	3 ≤ t ≤ 50 mm	215	260	9	8
	T6	3 ≤ t ≤ 10 mm	215	260	8	6
		10 ≤ t ≤ 50 mm	200	250	8	6
6061	T6	3 ≤ t ≤ 50 mm	240	260	10	8
6082	T5	3 ≤ t ≤ 50 mm	230	270	8	6
	T6	3 ≤ t ≤ 50 mm	250	290	6	
		3 ≤ t ≤ 50 mm	260	310	10	8

Notes:

1) The values are applicable for longitudinal and transverse tensile test specimens as well.
2) Elongation in 50 mm applies for thicknesses upto and including 12.5 mm and in 5d for thicknesses over 12.5 mm.

Table 2.8.3 : Mechanical properties for extruded closed profiles (testing transverse to extruding direction)

Grade	Temper condition	0.2% proof stress [N/mm^2]	Tensile strength [N/mm^2]	Elongation % min on gauge length of 5 x dia
6061	T5/T6	205	245	4
6005A	T5/T6	215	250	5
6082	T5/T6	240	290	5

2.9 Freedom from defects

2.9.1 The finished material is to have a good finish and is to be free from internal and surface defects prejudicial to the use of the concerned material for the intended application.

2.9.2 Slight surface imperfections may be removed by smooth grinding or machining as long as the thickness of the material remains within the tolerances given in 2.4.

2.10 Corrosion testing

2.10.1 Rolled 5xxx-alloys of type 5083, 5383, 5059, 5086 and 5456 in the H116 and H321 tempers intended for use in marine hull construction or in marine applications where frequent direct contact with seawater is expected, are to be corrosion tested with respect to exfoliation and intergranular corrosion resistance.

2.10.2 The manufacturers are to establish the relationship between microstructure and resistance to corrosion when the above alloys are approved. A reference photomicrograph taken at 500x under the conditions specified in ASTM B928, Section 9.4.1, is to be established for each of the alloy-tempers and relevant thickness ranges. The reference photographs are to be taken from samples which have exhibited no evidence of exfoliation corrosion and a pitting rating of PB or better, when subjected to the test described in ASTM G66 "Standard test method for visual assessment of exfoliation, corrosion susceptability of 5xxx series aluminium alloys" (ASSET Test). The samples are also to have exhibited resistance to intergranular corrosion at a mass loss not greater than 15 [mg/cm^2], when subjected to tests described in ASTM G67 "Standard test method for determining the susceptibility to intergranular corrosion of 5xxx series aluminium alloys by mass loss after exposure to nitric acid" (NAMLT). Upon satisfactory establishment of the relationship between microstructure and resistance to corrosion, the master photomicrographs and the results of the corrosion tests are to be approved by IRS. Production practices are not to be changed after approval of the reference micrographs.

Other test methods may also be accepted at the discretion of IRS.

2.10.3 For batch acceptance of 5xxx-alloys in the H116 and H321 tempers, metallographic examination of one sample selected from mid width at one end of a coil or random sheet or plate is to be carried out. The microstructure of the sample is to be compared to the reference photomicrograph of acceptable material in the presence of the Surveyor. A longitudinal section perpendicular to the rolled surface is to be prepared for metallographic examination under the conditions specified in ASTM B928, Section 9.6.1. If the microstructure shows evidence of continuous grain boundary network of aluminium-magnesium precipitate in excess of the reference photomicrographs of acceptable material, the batch is either to be rejected or tested for exfoliation-corrosion resistance and intergranular corrosion resistance subject to the agreement of the Surveyor. The corrosion tests are to be in accordance with ASTM G66 and G67 or equivalent standards. Acceptance criteria are as noted below:

i) The sample is to exhibit no evidence of exfoliation corrosion
ii) The pitting rating of the sample is to be PB or better when subjected to ASTM G66 ASSET test
iii) The sample is to exhibit resistance to intergranular corrosion at a mass loss no greater than 15 [mg/cm^2] when subjected to ASTM G67 NAMLT test.

If the results from testing satisfy the acceptance criteria the batch is accepted, else it is to be rejected.

As an alternative to metallographic examination, each batch may be tested for exfoliation-corrosion resistance and intergranular corrosion resistance, in accordance with ASTM G66 and G67 under the conditions specified in ASTM B928 or equivalent standards. If this alternative is used, then the results of the test must satisfy the acceptance criteria stated above.

2.11 Test materials

2.11.1 Definition of batches
Each batch is made up of products:

- of the same alloy grade and from the same cast
- of the same product form and similar dimensions (for plates, the same thickness)
- manufactured by the same process
- having been submitted simultaneously to the same temper condition.

2.11.2 The test samples are to be taken

- at one third of the width from a longitudinal edge of rolled products.
- in the range 1/3 to 1/2 of the distance from the edge to the centre of the thickest part of extruded products.

2.11.3 Test samples are to be taken so that the orientation of test specimens is as follows:

a) Rolled products

Normally, tests in the transverse direction are required. If the width is insufficient to obtain transverse test specimen, or in the case of strain hardening alloys, tests in the longitudinal direction will be permitted.

b) Extruded products

The extruded products are tested in longitudinal direction.

2.11.4 After removal of test samples, each test specimen is to be marked in order that its original identity, location and orientation is maintained.

2.12 Mechanical test specimens

2.12.1 Type and location of tensile test specimens are to be in accordance with details given in Ch.2.

2.13 Number of test specimens

2.13.1 Tensile test

a) Rolled products

- One tensile test specimen is to be taken from each batch of the product. If the weight of one batch exceeds 2000 [kg], one extra tensile test specimen is to be taken from every 2000 [kg] of the product or fraction thereof, in each batch.
- For single plates or for coils weighing more than 2000 [kg] each, only one tensile test specimen per plate or coil shall be taken.

b) Extruded products

- For the products with a nominal weight of less than 1 [kg/m], one tensile test specimen is to be taken from each 1000 [kg], or fraction thereof, in each batch. For nominal weights between 1 and 5 [kg/m], one tensile test specimen is to be taken from each 2000 [kg] or fraction hereof, in each batch. If the nominal weight exceeds 5 [kg/m], one tensile test specimen is to be taken for each 3000 [kg] of the product or fraction thereof, in each batch.

2.13.2 Corrosion tests

For rolled plates of grade 5083, 5383, 5059 and 5086 delivered in the tempers H116 or H321, one sample is to be tested per batch.

2.14 Retest procedures

2.14.1 When the tensile test from the first piece selected in accordance with Sec.11 fails to meet the requirements, two further tensile tests may be made from the same piece. If both of these additional tests are satisfactory, this piece and the remaining pieces from the same batch may be accepted.

2.14.2 If one or both the additional tests referred to above are unsatisfactory, the piece is to be rejected, but the remaining material from the same batch may be accepted provided that two of the remaining pieces in the batch selected in the same way, are tested with satisfactory results. If unsatisfactory results are obtained from either of these two pieces then the batch of material is to be rejected.

2.14.3 In the event of any material bearing the Classification Society's brand failing to comply with the test requirements, the brand is to be unmistakably defaced by the manufacturer.

2.15 Visual and non-destructive examination

2.15.1 Surface inspection and verification of dimensions are the responsibility of the manufacturer, and acceptance by the Surveyors of material later found to be defective shall not absolve the manufacturer from this responsibility.

2.15.2 In general, the non-destructive examination of materials is not required for acceptance purposes. Manufacturers are expected, however to employ suitable methods of non-destructive examination for the general maintenance of quality standards.

2.15.3 For applications where the non-destructive examination of materials is considered to be necessary, the extent of this examination, together with appropriate acceptance standards, are to be agreed between the purchaser, manufacturer and Surveyor.

2.16 Rectification of defects

2.16.1 Local surface defects may be removed by machining or grinding, provided the thickness of the material remains within the tolerances given in para 2.4. The extent of repairs is to be agreed upon with the Surveyor, and all repairs are to be carried out under Surveyor's supervision, unless otherwise arranged.

2.16.2 Surface defects which cannot be dealt with as in 2.12.1 are not allowed to be repaired, unless it can be ensured that repair by welding does not affect the strength and stability of the piece for the intended purpose. Any case of repair by welding is to be specified in detail for consideration and approval by the Surveyor. Prior to any such repair welding, the defect is to be removed by machining or grinding. After complete removal of the defect and before welding the thickness of the piece at no place is to be reduced by more than 20 per cent. The welding is to be carried out by approved welders. The weld is to be ground flush with the surrounding piece surface. Before repair welding is commenced and after grinding the weld bead, suitable non destructive testing may be required at the discretion of the Surveyor.

2.17 Identification

2.17.1 The manufacturer is to adopt a system of identification which will ensure that all finished material in a batch presented for test is of the same nominal chemical composition.

2.17.2 Products are to be clearly marked by the manufacturer in accordance with the requirements of Ch.1. The following details are to be shown on all materials which have been accepted:

a) Manufacturer's name or trade mark;

b) Grade of alloy;

c) Identification mark which will enable the full history of the item to be traced;

d) Abbreviated designation of temper condition in accordance with para 2.6;

e) Personal stamp of the Surveyor responsible for the final inspection and also IRS's stamp.

f) Tempered grades that are corrosion tested in accordance with 2.12 are to be marked "M" after the temper condition, e.g. 5083 H321 M.

2.17.3 When extruded products are bundled together or packed in crates for delivery, the marking specified in para 2.17.2 are to be affixed by a securely fastened tag or label.

2.18 Certification

2.18.1 Each test certificate or shipping statement is to include the following particulars :

a) Purchaser's name and order number;

b) Contract number;

c) Address to which material is to be dispatched;

d) Description and dimensions;

e) Specification or grade of alloys;

f) Identification mark which will enable the full history of the item to be traced;

g) Chemical composition;

h) Mechanical test results (Not required on shipping statement);

i) Details of heat treatment, where applicable; and

j) Corrosion test results (if any).

2.18.2 Where the alloy is not produced at the works at which it is wrought, a certificate is to be supplied by the Manufacturer of the alloy stating the cast number and chemical composition. The works at which alloys are produced must be approved by IRS.

Section 3

Aluminium Alloy Castings

3.1 Scope

3.1.1 Provision is made in this section for aluminium alloy castings intended for use in the construction of ships, ships for liquid chemicals and other marine structures, liquefied gas piping systems where the design temperature is not lower than minus 165°C. These materials should not be used for piping outside cargo tanks except for short lengths of pipes attached to cargo tanks in which case fire resisting insulation should be provided.

3.1.2 Castings are to be manufactured and tested in accordance with Ch.1 and Ch.2 and also with the requirements of this Section.

3.1.3 As an alternative to 3.1.2, castings which comply with National/International and proprietary specifications may be accepted provided that these specifications give reasonable equivalence to the requirements of this Section or are approved for a specific application. Generally survey and certification are to be carried out in accordance with the requirements of Ch.1.

3.2 Manufacture

3.2.1 Castings are to be manufactured at foundries approved by IRS.

3.3 Quality of castings

3.3.1 All castings are to be free from surface or internal defects which would be prejudicial to their proper application in service.

3.4 Chemical composition

3.4.1 The chemical composition of a sample from each cast is to comply with the requirements given in Table 3.4.1. Suitable grain refining elements may be used at the discretion of the Manufacturer. The content of such elements is to be reported in ladle analysis.

3.4.2 Where it is proposed to use alloys not specified in Table 3.4.1 details of chemical composition, heat treatment and mechanical properties are to be submitted for approval.

3.4.3 When a cast is wholly prepared from ingots for which an analysis is already available, and provided that no significant alloy additions are made during melting, the ingot maker's certified analysis can be accepted subject to occasional checks as required by the Surveyor.

Table 3.4.1 : Chemical composition for aluminium alloy castings

Alloy Element %	Grade			
	AlMg3	**AlSi12**	**AlSi10Mg**	**AlSi7 High purity**
Copper	0.1 max	0.1 max.	0.1 max.	0.1 max.
Magnesium	2.5 - 4.5	0.1 max.	0.15 - 0.4	0.25 - 0.45
Silicon		0.5 max. 11.0 - 13.5	9.0 - 11.0	6.5 - 7.5
Iron	0.5 max.	0.7 max.	0.6 max.	0.2 max.
Manganese	0.6 max.	0.5 max.	0.6 max.	0.1 max.
Zinc	0.2 max.	0.1 max.	0.1 max.	0.1 max.
Chromium	0.1 max.	-	-	-
Titanium	0.2 max.	0.2 max.	0.2 max.	0.2 max.
Others				
each	0.05 max.	0.05 max.	0.05 max.	0.05 max.
Total	0.15 max.	0.15 max.	0.15 max.	0.15 max.
Aluminium	Remainder	Remainder	Remainder	Remainder

3.5 Heat treatment

3.5.1 Castings are to be supplied in the following conditions:

Grade Al-Mg 3	As manufactured
Grade Al-Si 12	As manufactured
Grade Al-Si 10 Mg	As manufactured or solution heat treated and precipitation hardened
Grade Al-Si 7 Mg	Solution heat treated and precipitation (high purity) hardened

3.6 Mechanical tests

3.6.1 At least one tensile specimen is to be tested from each cast, where heat treatment is involved, for each treatment batch from each cast. Where continuous melting is employed 500 [kgs] of fettled castings may be regarded as a cast.

3.6.2 The test samples are to be separately cast in moulds made from the same type of material as used for the castings. These moulds should conform to National Standards.

3.6.3 The methods and procedures for the identification of the test specimens, and the castings they represent, are to be agreed with the Surveyor. The identification marks are to be maintained during the preparation of test specimens.

3.6.4 Where castings are supplied in the heat treated condition, the test samples are to be heat treated together with the castings which they represent prior to testing.

3.6.5 The results of all tensile tests are to comply with the appropriate requirements given in Table 3.6.1 and/or Table 3.6.2.

Table 3.6.1 : Minimum mechanical properties for acceptance purpose of sand cast and investment cast reference test pieces

Alloy	Temper (see Note)	Tensile strength [N/mm^2]	Elongation %
AlMg3	M	150	5
AlSi12	M	150	3
AlSi10Mg	M	150	2
AlSi10Mg	TF	220	1
AlSi7Mg	TF	230	5

Note
M - As cast condition
TF - Solution heat treated and precipitation hardened condition

Table 3.6.2 : Minimum mechanical properties for acceptance purpose of chill cast reference test pieces

Alloy	Temper (see Note)	Tensile strength [N/mm^2]	Elongation %
AlMg3	M	150	5
AlSi12	M	170	3
AlSi10Mg	M	170	3
AlSi10Mg	TF	240	1.5
AlSi7Mg	TF	250	5

Note
M - As cast condition
TF - Solution heat treated and precipitation hardened condition

3.7 Visual examination

3.7.1 All castings are to be cleaned and adequately prepared for inspection.

3.7.2 The accuracy and verification of dimensions are the responsibility of the manufacturer, unless otherwise agreed.

3.7.3 Before acceptance, all castings are to be presented to the Surveyor for visual examination.

3.8 Rectification of defective castings

3.8.1 At the discretion of the Surveyor, small surface blemishes may be removed by local grinding.

3.8.2 Where appropriate, repair by welding may be accepted at the discretion of the Surveyor. Such repair is to be made in accordance with an approved procedure.

3.9 Pressure testing

3.9.1 Where required by the relevant construction rules, castings are to be pressure tested before final acceptance. Unless otherwise agreed, these tests are to be carried out in the presence and to the satisfaction of the Surveyor.

3.10 Identification

3.10.1 The manufacturer is to adopt a system of identification which will enable all finished castings to be traced to the original cast and the Surveyor is to be given full facilities for tracing the casting when required.

3.10.2 All castings which have been tested and inspected with satisfactory results are to be clearly marked with following details :

a) Identification number, cast number or other numbers which will enable the full history of the casting to be traced;

b) IR and the abbreviated name of local office of IRS;

c) Personal stamp of the surveyor responsible for the inspection;

d) Test pressure where applicable; and

e) Date of final inspection.

3.10.3 Where small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with the Surveyor.

3.11 Certification

3.11.1 The manufacturer is to provide the Surveyor with a written statement giving the following particulars for each casting or batch of castings which have been accepted :

a) Purchaser name and order number;

b) Description of castings and alloy type;

c) Identification number;

d) Ingot or Cast analysis;

e) General details of heat treatment where applicable;

f) Results of mechanical tests; and

g) Test pressure, where applicable.

Section 4

Aluminium/Steel Transition Joints

4.1 Scope

4.1.1 Provision is made in this section for explosion bonded composite aluminium/steel transition joints used for connecting aluminium structures to steel plating.

4.1.2 Each design is to be separately approved by IRS.

4.2 Manufacture

4.2.1 Transition joints are to be manufactured by an approved producer in accordance with an approved specification which is to include the maximum temperature allowable at the interface during welding.

4.2.2 The aluminium material is to comply with the requirements of Sec.1 and the steel is to be of an appropriate grade complying with the requirements of Ch.3.

4.2.3 Alternative materials which comply with International, National or proprietary specifications may be accepted provided that they give reasonable equivalence to the requirements of 4.2.2 or are approved for a specific application.

4.2.4 Intermediate layers between aluminium and steel may be used, in which case the material of any such layer is to be specified by the manufacturer and will be recorded in the approval certificate. Any such intermediate layer is then to be used in all production joints.

4.3 Visual and non-destructive examination

4.3.1 Each composite plate is to be subjected to 100 per cent visual and ultrasonic examination in accordance with a relevant National/ International standard to determine the extent of any unbounded areas. The unbounded areas are unacceptable and any such area and the surrounding 25 [mm] area is to be discarded.

4.4 Mechanical tests

4.4.1 Two shear test specimens and two tensile test specimens are to be taken from each end of each composite plate for tests to be made on bond strength. One shear and one tensile test specimen from each end are to be tested at ambient temperature after heating to the maximum allowable interface temperature; the other two specimens are to be tested without heat treatment.

4.4.2 Shear tests may be made on a specimen as shown in Fig.4.4.1 or an appropriate equivalent. Tensile tests may be made across the interface by welding extension pieces to each surface or by the ram method shown in Fig.4.4.2 or by an appropriate alternative method.

4.4.3 The shear and tensile strengths of all the test specimens are to comply with the requirements of the manufacturing specification.

4.4.4 If either the shear or tensile test strength of the bond is less than the specified minimum but not less than 70 per cent of the specified minimum, two additional shear and two tensile test specimens from each end of the composite plate are to be tested and, in addition bend tests as described in 4.4.6 and Table 4.4.1 are to be conducted.

4.4.5 If either the shear or the tensile strength of the bond is less than 70 per cent of the specified minimum the case is to be investigated. After evaluation of the results of this investigation IRS will consider the extent of composite plate which is to be rejected.

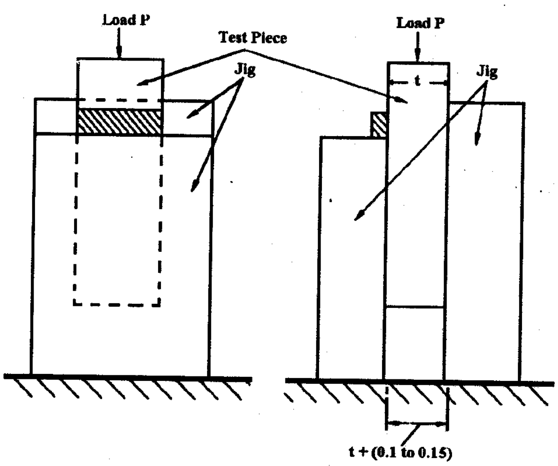


Fig.4.4.1 : Shear tests

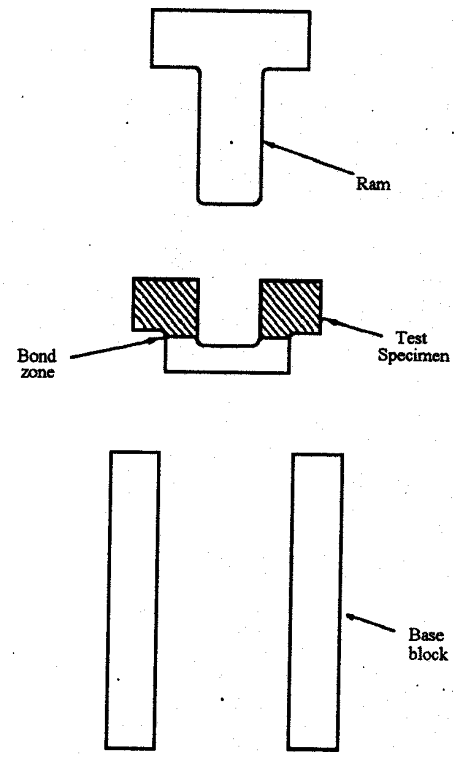


Fig.4.4.2 : Tensile tests

4.4.6 Bend tests, when required, are to be made under the following conditions, as listed in Table 4.4.1 :

a) the aluminium plate is in tension;

b) the steel plate is in tension; and

c) a side bend is applied.

Table 4.4.1 : Bend tests on explosion bonded aluminium / steel transition joints

Type of test	Minimum bend, degrees	Diameter of former
Aluminium in tension	90	3T
Steel in tension	90	3T
Side bend	90	6T

4.5 Identification

4.5.1 Each acceptable transition strip is to be clearly marked with IRS brand IR and the following particulars :

a) Manufacturers name or trade mark;

b) Identification mark for the grade of aluminium; and

c) Identification mark for the grade of steel.

The particulars are to be stamped on the aluminium surface at one end of the strip.

4.6 Certification

4.6.1 Each test certificate or shipping statement is to include the following particulars :

a) Purchaser's name and order number;

b) The contract number for which the material is intended, if known;

c) Address to which the material is dispatched;

d) Description and dimensions of the material;

e) Specification or grades of both the aluminium alloy and the steel and any intermediate layer;

f) Cast numbers of steel and aluminium plates;

g) Identification number of the composite plate; and

h) Mechanical test results (not required on the shipping statement).

End of Chapter

Chapter 10

Equipment

Contents

Section

Section 1

Anchors

1.1 Scope

1.1.1 The following paragraphs give requirements for cast, forged or fabricated steel anchor heads, shanks and anchor shackles. The requirements given in this section are applicable to the following types of anchors:

a) Ordinary stockless and stocked anchors
b) High Holding Power (HHP) anchors, and
c) Super High Holding Power (SHHP) anchors not exceeding 1500 [kg] in mass.

1.2 Manufacture

1.2.1 Cast steel anchor heads, shanks and shackles are to be manufactured and tested in accordance with the relevant requirements for castings for welded construction of Ch.4. The steel is to be fine grain treated with aluminium. The toughness of steel castings for SHHP anchors is to be not less than charpy V-notch energy average of 27 J at 0°C.

1.2.2 Forged steel anchor heads, shanks, shackles and anchor crown pins are to be manufactured in accordance with the requirements for forgings of weldable quality of Ch.5.

1.2.3 Plate material and bars used for the manufacture of fabricated parts of steel anchors are to comply with the requirements of Ch.3. For welded super high holding power (SHHP) anchors, the base steel grades are to be selected with respect to the material grade requirements for Class II in Part 3, Chapter 2 'Materials of Construction' Section 2 'Use of Steel Grades'.

1.2.4 The welding consumables are to meet the toughness for the base steel grades in accordance with Part 2, Chapter 11 'Approval of Welding Consumables for Use in Ship Construction'.

1.2.5 Fabrication is to be carried out by qualified welders using approved welding procedure.

1.2.6 The toughness of the anchor shackles for SHHP anchors is to meet that for Grade CC3 anchor chain given in Section 2. The toughness of steel castings for SHHP anchors is to be not less than charpy V-notch energy average of 27 J at 0°C.

1.2.7 Hardness values of mating parts are to be such that the more easily replaceable part wears faster.

1.3 Dimensions and tolerances

1.3.1 Anchors are to be manufactured as per approved drawings or as per internationally recognised designs meeting the tolerances specified in such documents. In addition the following dimensional tolerances are also to be applied:

- the clearance either side of the shank within the shackle jaws is not to be more than 3 [mm] for anchors upto 3000 [kg] mass, 4 [mm] for anchors upto 5000 [kg] mass, 6 [mm] for anchors upto 7000 [kg] mass and 12 [mm] for larger anchors.

- the shackle pin is to be push fit in the eyes of the shackle, which are to be chamfered on the outside to ensure tightness when the pin is clenched over. The shackle pin to hole clearance is not to be more than 0.5 [mm] for pins upto 57 [mm] and not more than 1 [mm] for pins of larger diameter

- the anchor crown pin is to be snug fit within the chamber and long enough to prevent horizontal movement. The gap is not to be more than 1% of the chamber length.

- The lateral movement of the shank should not exceed 3 degrees.

1.4 Proof test of anchors

1.4.1 Anchors of all sizes are to be proof load tested with the load specified in Table 1.4.1. Anchors having a mass of 75 [kgs] or more inclusive of stock (56 [kgs] in case of high holding power anchors) are to be tested at a proving establishment recognized by IRS.

1.4.2 The proof test load is to be as given in Table 1.4.1. The mass to be used in the Table is to be as follows:-

a) For stockless anchors - the total mass of the anchor;

b) For stocked anchors - the mass of the anchor excluding the stock;

c) For high holding power anchors - a nominal mass equal to 1.33 times the actual mass of the anchor;

d) For super high holding power anchors - a nominal mass equal to 2.0 times the actual mass of the anchor.

1.4.3 The proof load is to be applied on the arm or on the palm at a spot which, measured from the extremity of the bill, is one-third of the distance between it and the centre of the crown.

In the case of the stockless anchors, both arms are to be tested at the same time, first on one side of the shank, then reversed and tested on the other.

1.4.4 Before application of proof test load the anchors are to be examined to be sure that castings are reasonably free of surface imperfections of harmful nature.

On completion of the proof load tests the anchors are to be examined for cracks and other defects and for anchors made in more than one piece, the anchors are to be examined for free rotation of their heads over the complete angle.

In every test the difference between the gauge lengths (shown in Fig.1.4.4), where one-tenth of the required load was applied first and where the load has been reduced to one-tenth of the required load from the full load, is not to exceed one percent (1%).

1.4.5 In addition to the requirements given in this Chapter attention must be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

Table 1.4.1 : Proof test load of anchors

Mass of anchor [kg] (1)	**Proof test load [kN] (2)**	**Mass of anchor [kg] (3)**	**Proof test load [kN] (4)**	**Mass of anchor [kg] (5)**	**Proof test load [kN] (6)**
50	23.2	2000	349.0	7000	804.0
55	25.2	2100	362.0	7200	818.0
60	27.1	2200	376.0	7400	832.0
65	28.9	2300	388.0	7600	845.0
70	30.7	2400	401.0	7800	861.0
75	32.4	2500	414.0	8000	877.0
80	33.9	2600	427.0	8200	892.0
90	36.3	2700	438.0	8400	908.0
100	39.1	2800	450.0	8600	922.0
120	44.3	2900	462.0	8800	936.0
140	49.0	3000	474.0	9000	949.0
160	53.3	3100	484.0	9200	961.0
180	57.4	3200	495.0	9400	975.0
200	61.3	3300	506.0	9600	987.0
225	65.8	3400	517.0	9800	998.0
250	70.4	3500	528.0	10000	1010.0
275	74.9	3600	537.0	10500	1040.0
300	79.5	3700	547.0	11000	1070.0
325	84.1	3800	557.0	11500	1090.0
350	88.8	3900	567.0	12000	1110.0
375	93.4	4000	577.0	12500	1130.0
400	97.9	4100	586.0	13000	1160.0
425	103.0	4200	595.0	13500	1180.0
450	107.0	4300	604.0	14000	1210.0
475	112.0	4400	613.0	14500	1230.0
500	116.0	4500	622.0	15000	1260.0
550	125.0	4600	631.0	15500	1270.0
600	132.0	4700	638.0	16000	1300.0
650	140.0	4800	645.0	16500	1330.0
700	149.0	4900	653.0	17000	1360.0
750	158.0	5000	661.0	17500	1390.0
800	166.0	5100	669.0	18000	1410.0
850	175.0	5200	677.0	18500	1440.0
900	182.0	5300	685.0	19000	1470.0
950	191.0	5400	691.0	19500	1490.0
1000	199.0	5500	699.0	20000	1520.0
1050	208.0	5600	706.0	21000	1570.0
1100	216.0	5700	713.0	22000	1620.0
1150	224.0	5800	721.0	23000	1670.0
1200	231.0	5900	728.0	24000	1720.0
1250	239.0	6000	735.0	25000	1770.0
1300	247.0	6100	740.0	26000	1800.0
1350	255.0	6200	747.0	27000	1850.0
1400	262.0	6300	754.0	28000	1900.0
1450	270.0	6400	760.0	29000	1940.0
1500	278.0	6500	767.0	30000	1990.0
1600	292.0	6600	773.0	31000	2030.0
1700	307.0	6700	779.0	32000	2070.0
1800	321.0	6800	786.0	34000	2160.0
1900	335.0	6900	794.0	36000	2250.0

Table 1.4.1 : Proof test load of anchors (Contd.)

Mass of anchor [kg] (1)	Proof test load [kN] (2)	Mass of anchor [kg] (3)	Proof test load [kN] (4)	Mass of anchor [kg] (5)	Proof test load [kN] (6)
38000	2330.0	42000	2490.0	46000	2650.0
40000	2410.0	44000	2570.0	48000	2730.0
Proof loads for intermediate masses are to be determined by linear interpolation					

Notes

Where ordinary anchors have a mass exceeding 48 000 [kg], the proof loads are to be taken as 2.059 (mass of anchor in kg)$^{2/3}$ [kN].

Where high holding power anchors have a mass exceeding 38 000 [kg], the proof loads are to be taken as 2.452 (actual mass of anchor in kg)$^{2/3}$ [kN].

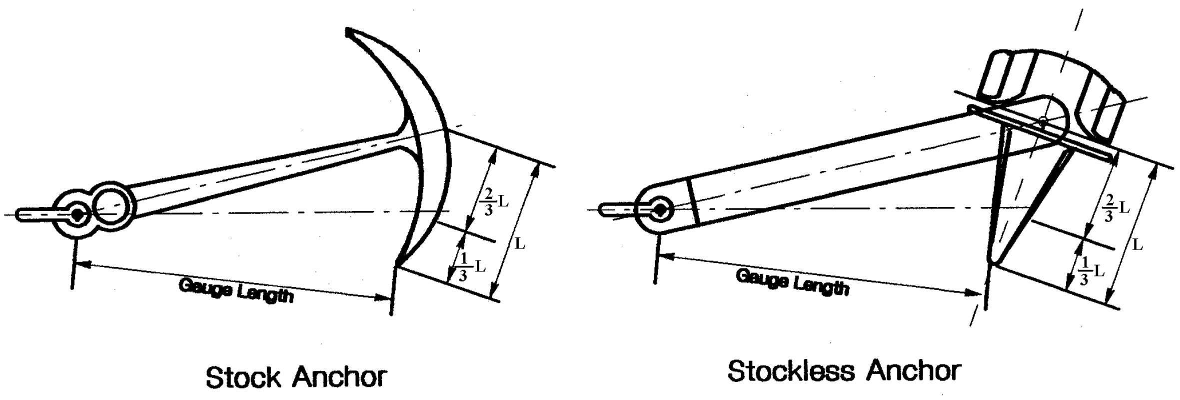


Fig.1.4.4 : Gauge Length

1.5 Inspections and other tests

1.5.1 Inspection and testing of anchor components is to be carried out as per the following:

a) Cast components are to be tested as per

Test Programme A

or

Test Programme B, where the Charpy V notch energy average of the cast material at 0°C is not less than 27J.

b) Forged / fabricated components are to be tested as per Test Programme B.

Test Programme A is to consist of Drop Test, Hammering Test, Visual Inspection and General NDE as described below.

Test Programme B is to consist of Visual Inspection, general NDE and Extended NDE as described in 1.5.5 and 1.5.6 below.

1.5.2 Drop test is to be carried out by dropping each anchor component individually from a height of 4 [m] to an iron or steel slab. The iron or steel slab should be able to resist the impact. The component under test should not fracture.

1.5.3 Hammering test is to be carried on each fluke and shank, after the drop test, by hammering the component, hung clear off the ground using a non-metallic sling, with a hammer of not less than 3 [kg] mass, to check the soundness.

1.5.4 Visual inspection is to be carried out of all accessible surfaces after the proof load test.

1.5.5 General non-destructive examination is to be carried out, after proof load testing, as per Table 1.5.5.

1.5.6 Extended non-destructive examination is to be carried out, after proof load testing, as per Table 1.5.6.

Table 1.5.5 : General NDE for Anchors		
Location	**Method of NDE**	
	SHHP	**Ordinary / HHP**
Feeders of castings	DP or MP and UT	DP or MP
Risers of castings	DP or MP and UT	DP or MP
All surfaces of castings	DP or MP	Not required
Weld repairs	DP or MP	DP or MP
Forged components	Not required	Not required
Fabrication welds	DP or MP	DP or MP
DP : Dye Penetrant Test		
MP : Magnetic Particle Test		
UT : Ultrasonic Testing		

Table 1.5.6 : Extended NDE for ordinary, HHP and SHHP anchors	
Location	**Method of NDE**
Feeders of castings	DP or MP and UT
Risers of castings	DP or MP and UT
All surfaces of castings	DP or MP
Random areas of castings	UT
Weld repairs	DP or MP
Forged components	Not required
Fabrication welds	DP or MP
DP : Dye Penetrant Test	
MP : Magnetic Particle Test	
UT : Ultrasonic Testing	

1.6 Identification

1.6.1 All identification marks are to be stamped on one side of the anchor, on the shank and the fluke, at locations reserved solely for this purpose.

1.6.2 The following details are to be marked on all the anchors:-

a) IR and abbreviated name of local office of IRS issuing the certificate;

b) Number of the certificate;

c) Month and year of test;

d) Mass (also the letters 'HHP/SHHP', when approved for as high holding power anchor/super high holding power anchor);

e) Mass of stock (in case of stocked anchors);

f) Personal stamp of Surveyor responsible for inspection.

g) Manufacturer's mark

h) Unique cast identification number of shank and fluke, if applicable.

1.6.3 In addition to the markings detailed in 1.6.2, each important part of the anchor is to be plainly marked with the words 'forged steel' or 'cast steel' as appropriate.

1.7 Painting

1.7.1 Anchors are to be painted only on completion of all inspections and tests.

Section 2

Stud Link Chain Cables

2.1 Scope

2.1.1 The following requirements apply to the materials, design, manufacture and testing of stud link anchor chain cables and accessories used for ships.

2.1.2 Depending upon the nominal tensile strength of the chain cable steel used for manufacture, stud link chain cables are subdivided in to three grades, namely CC1, CC2 and CC3.

2.2 Manufacture

2.2.1 Chain cables and accessories are to be manufactured at Works approved by IRS for the pertinent type of chain cable, size and method of manufacture.

2.2.2 Chain cables are to be preferably manufactured by flash butt welding using material suitable for CC1, CC2 or CC3 grades of chain cables. Chain cables may also be manufactured by drop forging or casting.

Accessories such as shackles, swivels and swivel shackles are to be forged or cast in steel of at least grade CC2 material. The welded construction of these components will be specially considered.

2.2.3 Details of the method of manufacture and the specification of the steel are to be submitted for approval.

2.2.4 All materials used for the manufacture of chain cables and accessories are to be supplied by manufacturer's works approved by IRS. However, for Grade CC1 steel bars, approval of material manufacturer is not required.

For Grade CC3 steel bars, detailed material specifications including manufacturing procedure, deoxidation practice, specified chemical composition, heat treatment and mechanical properties are to be submitted.

2.3 Design and tolerances

2.3.1 The form and proportion of chain cable links and shackles are to be in accordance with ISO/1704-1991 (see Figs.2.3.1 to 2.3.6). All dimensions in the figures are shown in multiples of the nominal diameter d of the common link. The dimensions in brackets may be chosen for studless links in outboard end swivel pieces. Where designs do not comply with this and where accessories are of welded construction, plans giving full details of the design, manufacturing process and heat treatment are to be submitted for approval.

2.3.2 The following tolerances are applicable to links with the provision that the plus tolerance may be up to 5 per cent of the nominal diameter:

a)

Nominal diameter Measured at the Crown (see note)	**Max. minus tolerance**
Upto 40 [mm]	1 [mm]
Over 40 and upto 84 [mm]	2 [mm]
Over 84 and upto 122 [mm]	3 [mm]
Over 122 and upto 152 [mm]	4 [mm]
Over 152 and upto 184 [mm]	6 [mm]
Over 184 and upto 210 [mm]	7.5 [mm]

Note : Two measurements are to be taken at the same location: one in the plane of the link (see d_p in Fig.2.3.7) and one perpendicular to the plane of the link.

The cross sectional area of the crown must not have any negative tolerance. For the tolerances of the diameters of the weld, the approved manufacturer's specifications would be applicable;

Diameter measured at locations other than the crown is to have no negative tolerance. Plus tolerance may be up to 5 per cent of the nominal diameter.

a) The maximum allowable tolerance on assembly measured over a length of 5 links may equal +2.5 per cent but may not be negative (measured with the chain under tension after proof load test);

b) All other dimensions are subject to a manufacturing tolerance of ± 2.5 per cent, provided that all of the final link parts fit together properly;

c) Studs must be located in the links centrally and at right angles to the sides of the link, although the studs at each end of any length may also be located off-centre to facilitate the insertion of the joining shackle. The following tolerances are regarded as being inherent in the method of manufacture and will not be objected to provided the stud fits snugly and its ends lie practically flush against the inside of the link.

Maximum off-centre distance 'X'	10 per cent of the nominal diameter d
Maximum deviation "α" from the 90° position	4°

The tolerances are to be measured in accordance with Fig.2.3.7.

2.3.3 The following tolerances are applicable to accessories :

Nominal diameter : + 5 per cent, - 0 per cent
Other diameter : ± 2.5 per cent.

2.4 Material for welded chain cables and accessories

2.4.1 Bar material intended for the manufacture of welded chain cables is to be in accordance with the appropriate requirements of Ch.3. Rimming steel is not acceptable for this application.

2.4.2 Bars of the same nominal diameter are to be presented for test in batches of 50 tonnes or fraction thereof from the same cast. A suitable length from one bar in each batch is to be selected for test purposes.

2.4.3 In order to evaluate the suitability of the bar material the sample selected from each batch is to be tested in a heat treatment condition equivalent to that of the finished chain cable and accessories. For this purpose only the sample need be heat treated.

2.4.4 For all grades, one tensile test is to be taken from each sample selected. Additionally one set of three Charpy V-notch impact test specimens is to be prepared and tested as required in Table 2.4.1.

2.4.5 Where the dimensions allow, the test specimens are to be taken at approximately one-third of the radius from the outer surface as shown in Fig.2.4.1. For smaller diameters the test specimens are to be taken as close as possible to these positions.

2.4.6 The cross-sectional area of the tensile test specimen is to be not less than 150 [mm^2]. Alternatively, the tensile test specimen may be a suitable length of bar tested in full cross-section.

2.4.7 The impact test specimens are to be notched in the radial direction as shown in Fig.2.4.1.

2.4.8 The results of all the mechanical testing are to comply with the requirements of Table 2.4.1.

2.4.9 The average value obtained from one set of three impact test specimens is to comply with the requirements given in Table 2.4.1. One individual value only may be below the specified average value provided it is not less than 70% of that value.

If the Charpy V-notch impact test requirements are not achieved, a retest of three further specimens selected from the same sample as per 1.10.2 of Chapter 1 shall be permissible. Failure to meet the requirements will result in rejection of the test unit represented unless it can be clearly attributable to improper simulated heat treatment.

If the tensile test requirements are not achieved, a retest of two further specimens selected from the same sample shall be permissible. Failure to meet the specified requirements in either of the additional tests will result in rejection of the test unit represented unless it can be clearly attributable to improper simulated heat treatment.

2.4.10 If failure to pass the tensile test or the Charpy V-notch impact test is definitely attributable to improper heat treatment of the test sample, a new test sample may be taken from the same piece and re-heat treated. The complete test (both tensile and impact test) is to be repeated and the original results obtained may be disregarded.

2.4.11 The chemical composition of the steel bars is to be generally within the limits given in Table 2.4.2.

2.4.12 The tolerances on diameter and roundness of rolled steel bars are to be within the limits specified in Table 2.4.3 unless otherwise agreed.

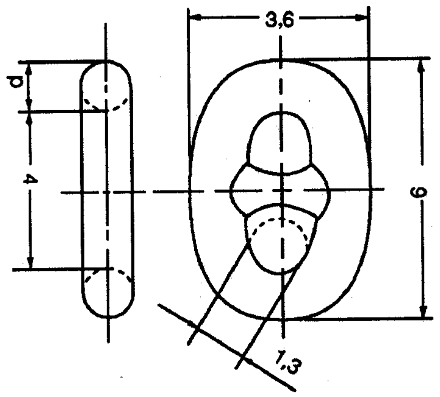


Fig. 2.3.1 : Common link

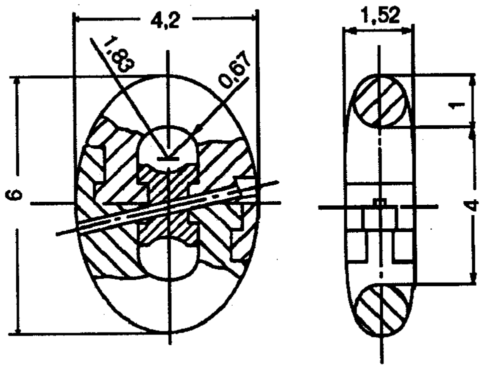


Fig. 2.3.5 : Kenter type lugless joining shackle

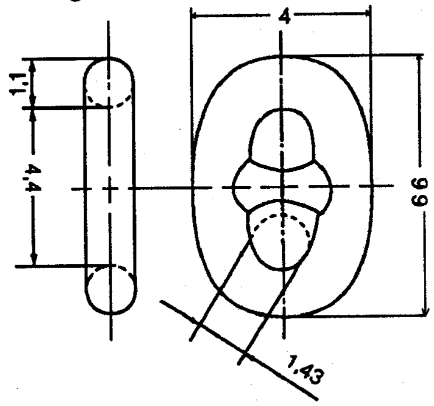


Fig. 2.3.2 : Enlarged link

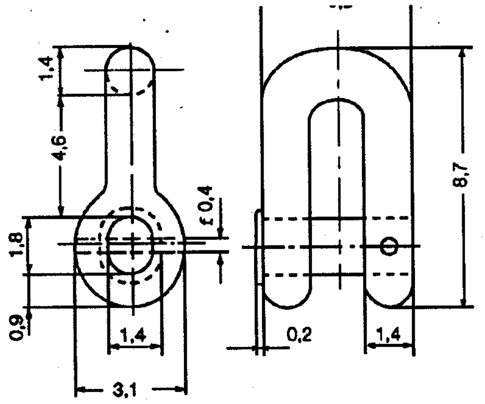


Fig. 2.3.6 : End shackle

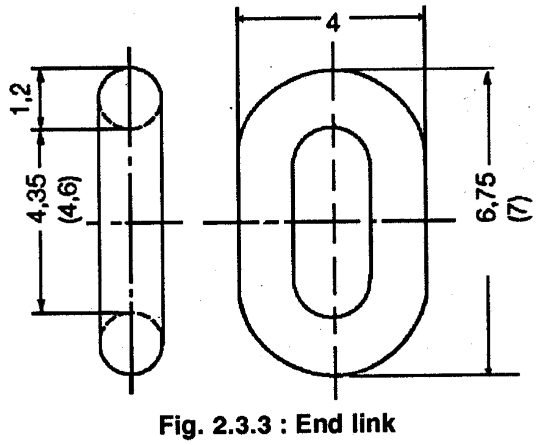


Fig. 2.3.3 : End link

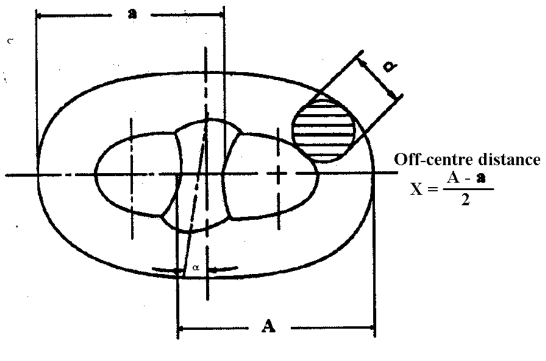


Fig. 2.3.7 : Link-stud tolerance

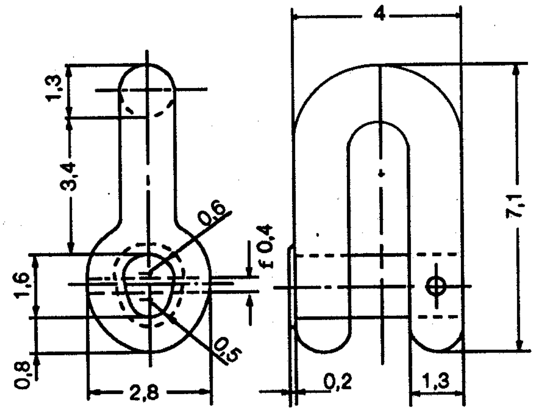


Fig. 2.3.4 : Joining shackle with shackle pin

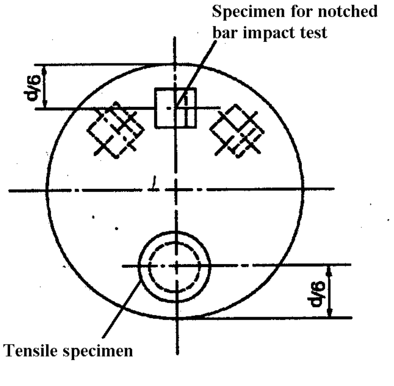


Fig. 2.4.1 : Position of test pieces

Table 2.4.1 : Mechanical properties of rolled steel bars for acceptance purposes

Designation	Tensile strength [N/mm^2]	Yield strength [N/mm^2] min.	Elongation on 5.65 $\sqrt{S_o}$% min.	Reduction of area % min.	Impact Tests	
					Test temp.°C	Average energy J min.[1]
Grade CC1	370 - 490	-	25	-	-	-
Grade CC2	490 - 690	295	22	-	0	27[1]
Grade CC3	Min. 690	410	17	40	0[2]	60
					-20	35

1 The impact test of grade CC2 material may be waived, if the chain is to be supplied in a heat treated condition as per Table 2.9.1.

2 The impact testing is normally to be carried out at 0°C.

Table 2.4.2 : Chemical composition of rolled steel bars

Designation	Chemical Composition					
	C max.	Si	Mn	P max.	S max.	Al (Total)[1] min.
Grade CC1	0.20	0.15 - 0.35	min. 0.40	0.040	0.040	-
Grade CC2[2]	0.24	0.15 - 0.55	max. 1.60	0.035	0.035	0.020
Grade CC3 [3]	To be specially considered in each case					

1 Aluminium may be replaced partly by other grain refining elements.

2 Subject to special consideration, additional alloying elements may be added.

3 To be killed and of fine grain.

Table 2.4.3 : Dimensional tolerance of rolled steel bars

Nominal diameter [mm]	Tolerance on diameter [mm]	Tolerance on roundness (dmax - dmin) [mm]
Less than 25	-0 + 1.0	0.6
25 – 35	-0 +1.2	0.8
36 – 50	-0 + 1.6	1.1
51 – 80	-0 + 2.0	1.5
81 – 100	-0 +2.6	1.95
101 – 120	-0 + 3.0	2.25
121 – 160	-0 + 4.0	3.0
161 – 210	-0 + 5.0	4.0

2.4.13 The minimum markings required for the steel bars are the manufacturers' brandmark, the steel grade and an abbreviated symbol of the heat. Steel bars having diameters of up to and including 40 mm and combined into bundles, may be marked on permanently affixed labels.

2.4.14 Material certification : Bar material for Grade 2 or Grade 3 is to be certified by IRS. For each consignment, manufacturers shall forward to the Surveyor a certificate containing at least the following data:

- Manufacturer's name and/or purchaser's order no.
- Number and dimensions of bars and weight of consignment
- Steel specification and chain grade
- Heat number
- Manufacturing procedure
- Chemical composition
- Details of heat treatment of the test sample (where applicable)
- Results of mechanical tests (where applicable)
- Number of test specimens (where applicable).

2.5 Material for cast chain cables and accessories

2.5.1 Manufacture of cast steel chain cables is generally to be in accordance with Ch.4, as appropriate.

2.5.2 All castings must be properly heat treated i.e. normalized, normalized and tempered or quenched and tempered, as specified in Table 2.7.1 for the relevant grade of steel.

2.6 Material for forged chain cables and accessories

2.6.1 The procedure for the manufacture of drop forgings for chain cables will be specially considered, but is generally to be in accordance with the appropriate requirements of Ch.5.

2.6.2 The stock material may be supplied in the as rolled condition. Finished forgings are to be properly heat treated, i.e. normalized, normalized and tempered or quenched and tempered, as specified for the relevant grade of steel in Table 2.7.1.

2.7 Heat treatment of completed chain cables

2.7.1 The completed chain cable and accessories are to be heat treated in accordance with Table 2.7.1, for the appropriate grade of cable.

2.7.2 In all cases, heat treatment is to be carried out prior to the proof, load test, breaking load test and all mechanical testing.

2.8 Materials and welding of studs

2.8.1 The studs are to be made of steel corresponding to that of the chain cable or from rolled, cast or forged mild steels. The use of other materials, e.g. grey or nodular cast iron is not permitted.

2.8.2 The welding of studs is to be in accordance with an approved procedure subject to following :

a) The studs being of weldable steel;

b) The studs being welded at one end only, i.e. opposite to the weldment of the link. The stud ends must fit inside of the link without appreciable gap;

Table 2.7.1 : Condition of supply of chain cables and accessories

Grade	Chain cables	Accessories
CC1	As welded or normalized	NA
CC2	As welded or normalized 1)	Normalized
CC3	Normalized, Normalized and tempered or Quenched and tempered	Normalized, normalized and tempered or Quenched and tempered

1) Grade CC2 chain cables made by forging or casting are to be supplied in the normalized condition

NA = Not Applicable.

c) The welds, preferably in the horizontal position, are to be executed by qualified welders using suitable welding consumables;

d) All the welds are to be completed before the final heat treatment of the chain cable; and

e) The welds are to be free from defects liable to impair the proper use of the chain.

2.9 Testing of completed chain cables

2.9.1 Finished chain cables are to be tested in the presence of a Surveyor, at a proving establishment recognized by IRS. For this purpose the chain cables must be free from paint and anti-corrosive media. Special attention would be given to the visual inspection of the flash-butt-weld, if present. In addition to the requirements of this Chapter, attention must be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

2.9.2 Each length of chain is to be subjected to a proof loading test in an approved testing machine and is to withstand the load given in Table 2.9.1 for the appropriate grade and size of cable. On completion of the test, each length of cable is to be examined and is to be free from significant defects.

Should a proof load test fail, the defective link(s) is (are) to be replaced, a local heat treatment to be carried out on the new link(s) and the proof load test is to be repeated. In addition, an investigation is to be made to identify the cause of the failure.

Table 2.9.1 : Formulae for proof load and breaking load tests

Test	Grade CC1	Grade CC2	Grade CC3
Proof load (kN)	$0.00686d^2$ (44 – 0.08d)	$0.00981d^2$ (44 – 0.08d)	$0.01373d^2$ (44 – 0.08d)
Breaking load (kN)	$0.00981d^2$ (44 – 0.08d)	$0.01373d^2$ (44 – 0.08d)	$0.01961d^2$ (44 – 0.08d)
Note d = nominal diameter [mm]			

Table 2.9.2 : Number of mechanical test specimens for finished chain cables and accessories

Grade	Manufacturing method	Condition of supply 1)	Number of test specimens		
			Tensile test for base metal	Charpy V-notch impact test	
				Base metal	Weldment
CC1	Flash-butt welded	AW N	NR	NR	NR
CC2	Flash-butt welded	AW -------------------- N	1 -------------------- NR	3 -------------------- NR	3 -------------------- NR
	Forged or Cast	N	1	3 [2]	NA
CC3	Flash-butt welded	N NT QT	1	3	3
	Forged or Cast	N NT QT	1	3	NA

1) AW = As Welded, N = Normalized, NT = Normalized and Tempered, QT = Quenched and Tempered

2) For chain cables, Charpy V-notch impact test is not required.

NR = Not required
NA = Not applicable

Table 2.9.3 : Mechanical properties of finished chain cables and accessories							
Grade	**Yield strength [N/mm^2] min.**	**Tensile strength [N/mm^2] min.**	**Elongation on 5.65 √So % min.**	**Reduction of area % min.**	**Charpy V-notch impact test**		
					Test tempera-ture, in C	**Absorbed energy, in Joules min.**	
						Base metal	**Weldment**
CC1	NR	NR	NR	NR	NR	NR	NR
CC2	295	490 – 690	22	NR	0	27	27
CC3	410	690 min.	17	40	0 [1)]	60	50
					-20	35	27
1) Testing is normally to be carried out at 0°C. NR = Not required.							

2.9.3 Sample lengths comprising of at least three links are to be taken from every four lengths or fraction of chain cables and tested at the breaking loads given in Table 2.9.1. The breaking load is to be maintained for a minimum of 30 seconds. The links concerned are to be made in a single manufacturing cycle together with the chain cable and must be welded and heat treated together with it. Only after this these may be separated from the chain cable in the presence of the Surveyor.

2.9.4 Where a breaking load test specimen fails, a further specimen is to be cut from the same length of cable and subjected to test. If this re-test fails, the length of cable from which it was taken is to be rejected. When this test is also representative of other lengths, each of the remaining lengths in the batch is to be individually tested and is to meet the requirements of the breaking load test.

2.9.5 For large diameter cables where the required breaking load is greater than the capacity of the testing machines, special consideration will be given to acceptance of other alternative testing procedure.

2.9.6 Mechanical test specimens required in Table 2.9.2 are to be taken from every four lengths in accordance with 2.9.7. For forged or cast chain cables where the batch size is less than four lengths, the sampling frequency is to be by heat treatment charge. Mechanical tests are to be carried out in the presence of the Surveyor. The test specimens and their location are to be according to 2.4.5 to 2.4.7 and Fig.2.4.1. Testing and re-testing are to be carried out as given in 2.4.9.

2.9.7 An additional link (or where the links are small, several links) for mechanical test specimen removal is to be provided in a length of chain cable not containing the specimen for the breaking test. The specimen link must be manufactured and heat treated together with the length of chain cable.

2.10 Accessories for chain cables

2.10.1 End and joining shackles, attachment links, adapter pieces, swivels and other fittings are to be subjected to the proof and breaking loads appropriate to the grade and size of cable for which they are intended in accordance with the requirements of Table 2.9.1.

2.10.2 The breaking load is to be applied to at least one item out of every 25 (one in 50 for lugless shackles). The items need not necessarily be representative of each heat of steel or individual purchase order. Enlarged links and end links need not be tested provided that they are manufactured and heat treated together with the chain cable. The tested item is to be destroyed and not used as part of an outfit, in general. However, the accessories, which have been successfully tested at the prescribed breaking load appropriate to the chain, may be used in service at the discretion of IRS where the accessories are manufactured with the following:

a) material having higher strength characteristics than those specified for the part in question (e.g. grade 3 material for accessories for grade 2 chain).

b) or alternatively, same grade material as the chain but with increased dimensions and it is verified by procedure tests that such accessories are so designed that the breaking strength is not less than 1.4 times the prescribed breaking load of the chain for which they are intended.

2.10.3 The breaking load test may be waived if –

a) The breaking load has been demonstrated on the occasion of the approval testing of parts of the same design, and

b) The mechanical properties of each manufacturing batch are approved, and

c) The parts are subjected to suitable non-destructive testing.

2.10.4 Unless otherwise specified, the forging or casting must at least comply with the mechanical properties given in Table 2.9.3, when properly heat treated. For test sampling, forgings or castings of similar dimensions originating from the same heat treatment charge and the same heat of steel are to be combined into one test unit. From each test unit, one tensile test specimen and the Charpy V-notch impact test specimens are to be taken in accordance with Table 2.9.2. Mechanical tests are to be carried out in the presence of the Surveyor. Location of test specimens and test procedure are to be as given in 2.4.5 to 2.4.7 and Fig.2.4.1. Testing / re-testing is to be carried out as per 2.4.9. Enlarged links and end links need not be tested provided they are manufactured and heat treated together with the chain cable.

2.11 Identification

2.11.1 All lengths of cables and accessories are to be stamped with the following identification marks:-

a) IR and the abbreviated name of the local office of IRS issuing the certificate;
b) Number of certificate;
c) Date of test;
d) Proof load and grade of chain;
e) Personal stamp of the Surveyor responsible for inspection.

Section 3

Short Link Chain Cables

3.1 General

3.1.1 Details regarding the form and proportions of short link chain cable, materials, method of manufacture and testing are to be submitted for special consideration by IRS.

3.1.2 In general the short link chain cables are to comply with the grades L(3) and M(4) of ISO 1834.

3.2 Testing and inspection of chain cables

3.2.1 All chain cable of 12.5 [mm] diameter and above, and all steering chains irrespective of diameter are to be tested at a proving establishment recognised by IRS. In addition to the requirements stated in this Chapter, attention is to be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

3.2.2 For chain of diameter less than 12.5 [mm], other than steering chains, the manufacturer's tests will be accepted.

3.2.3 After completion of all manufacturing processes, including heat treatment and galvanising, the whole of the chain is to be subjected to the appropriate proof load specified in Table 3.2.1.

3.2.4 The whole of the chain is to be inspected after the proof load test and is to be free from significant defects.

3.2.5 At least one sample, consisting of seven or more links, is to be selected by the Surveyor from each 200 [m] or less of chain for breaking load tests. Two additional links may be required for engagement in the jaws of the testing machine. These extra links are not to be taken into account in determining the total elongation (See 3.2.7).

3.2.6 The breaking load is to comply with the appropriate requirements of Table 3.2.1.

3.2.7 The total elongation of the breaking load sample at fracture, expressed as a percentage of the original inside length of the sample after proof loading, is to be not less than 20 per cent.

Table 3.2.1 : Mechanical test requirements for short link chain cables				
Chain diameter [mm]	**Grade L(3)**		**Grade M(4)**	
	Proof load [kN]	**Breaking load min. [kN]**	**Proof load [kN]**	**Breaking load min. [kN]**
5	-	-	7.9	15.8
6	9	18	-	-
6.3	-	-	12.5	25
7.1	-	-	15.9	31.8
8	16	32	20.2	40.4
9	-	-	25.5	51
10	25	50	31.5	63
11.2	-	-	39.5	79
12	35.5	71	-	-
12.5	-	-	49.1	98.2
14	-	-	63	126
16	-	-	81	162
18	-	-	102	204
20	-	-	126	252
22.4	-	-	158	316
25	-	-	197	394
28	-	-	247	494
32	-	-	322	644
36	-	-	408	816
40	-	-	503	1006
45	-	-	637	1274

Section 4

Steel Wire Ropes

4.1 General

4.1.1 Steel wire ropes are to be manufactured at Works approved by IRS.

4.1.2 The wire ropes are to be of six strand type with minimum of 16 wires in each strand. In addition to complying with the requirements of this Chapter, the details regarding form of construction and minimum breaking strength are to be in accordance with IS: 2266-1989. Alternative type of wire ropes will be specially considered on the basis of an equivalent breaking load and the suitability of the construction for the purpose intended.

4.1.3 It is recommended that the wire ropes intended for stream wires, towlines and mooring lines be of fiber core construction and wire ropes for towlines and mooring lines used in association with mooring winches be of wire rope core.

4.2 Materials

4.2.1 The wire used in the manufacture of the rope is to be drawn from steel made in accordance with the requirements of Ch.3.

Table 4.2.1 : Torsion test - Speed of testing	
Diameter of coated wire [mm]	Maximum speed of testing twists per minute
< 1.5	90
≥ 1.5 < 3.0	60
≥ 3.0 < 4.0	30

4.2.2 The tensile strength is generally to be within the ranges 1420 to 1570 [N/mm^2]; 1570 to 1770 [N/mm^2] or 1770 to 1960 [N/mm^2].

4.2.3 The wire is to be galvanized by a hot dip or electrolytic process to give a uniform coating which may be any of the following grades:-

Grade 1 : heavy coating, drawn after galvanizing;

Grade 2 : heavy coating, finally galvanized;

Grade 3 : light coating, drawn after galvanizing.

4.2.4 Torsion and zinc coating tests are to be carried out on wire samples taken from a suitable length of the completed rope. After unstranding and straightening, six wires are to be subjected to both a torsion test and a wrap test for adhesion of coating. Additionally, tests to determine the uniformity of the zinc coating are to be carried out.

4.2.5 As an alternative to test specimens taken as detailed in 4.2.4, tests may be carried out on the wire before the rope is stranded.

4.2.6 For the torsion test, the length of the sample is to be such as to allow a length between the grips of 100 times the wire diameter or 300 [mm], whichever is less. The wire is to be twisted by causing one or both of the vices to be revolved until fracture occurs. The speed of testing is not to exceed, for a length equal to 100 times the diameter, that given in Table 4.2.1 (a tensile load not exceeding 2 per cent of the breaking load of the wire may be applied to keep the wire stretched). The wire is to withstand, without fracture on a length of 100 times the diameter of wire, the number of complete twists given in Table 4.2.2.

Table 4.2.2 : Torsion test - Minimum number of twists

Diameter of coated wire [mm]	Minimum number of twists			
	Grade 2		Grade 1 or 3	
	Tested before stranding	Tested after stranding	Tested before stranding	Tested after stranding
< 1.3	15	13	27	24
≥ 1.3 < 2.3	15	13	26	23
≥ 2.3 < 3.0	14	12	23	20
≥ 3.0 < 4.0	12	10	21	18

4.3 Zinc coating tests

4.3.1 The mass per unit area of the zinc coating is to be determined in accordance with a recognised standard and is to comply with the minimum values given in Table 4.3.1.

Table 4.3.1 : Zinc coating

Diameter of coated wire [mm]	Zinc coating [grams/m^2]	
	Grade 1 or 2	Grade 3
≥ 0.40 < 0.50	75	40
≥ 0.50 < 0.6	90	50
≥ 0.6 < 0.8	110	60
≥ 0.8 < 1.0	130	70
≥ 1.0 < 1.2	150	80
≥ 1.2 < 1.5	165	90
≥ 1.5 < 1.9	180	100
≥ 1.9 < 2.5	205	110
≥ 2.5 < 3.2	230	125
≥ 3.2 < 4.0	250	135

4.3.2 The uniformity of the zinc coating is to be determined by a dip test carried out in accordance with the requirements of a recognized standard.

4.3.3 The adhesion of the coating is to be tested by wrapping the wire round a cylindrical mandrel for 10 complete turns. The ratio between the diameter of the mandrel and that of the wire is to be as in Table 4.3.2. After wrapping on the appropriate mandrel the zinc coating is to have neither flaked nor cracked to such an extent that any zinc can be removed by rubbing with bare fingers.

Table 4.3.2 : Wrap test for adhesion of zinc coating

Coating	Diameter coated wire [mm]	Max. ratio of mandrel to wire diameter
Grade 1 and 2	< 1.5	4
	≥ 1.5	6
Grade 3	< 1.5	2
	≥ 1.5	3

4.4 Test on completed ropes

4.4.1 The breaking load is to be determined by testing to destruction a sample cut from the completed rope. This sample is to be of sufficient length to provide a clear test length of at least 36 times the rope diameter between the grips.

4.4.2 The actual breaking load is not to be less than that given in the appropriate approved standard.

4.5 Identification

4.5.1 All completed ropes are to be identified with attached labels detailing the rope type, diameter and length.

Section 5

Offshore Mooring Chains

5.1 Scope

5.1.1 Following requirements apply to the materials, design, manufacture and testing of offshore mooring chain and accessories intended to be used for application such as: mooring of mobile offshore drilling units, mooring of floating production units, mooring of offshore loading systems and mooring of gravity based structures during fabrication.

5.1.2 Mooring equipment covered by these requirements are common stud and studless links, connecting common links (splice links), enlarged links, end links, detachable connecting links (shackles), end shackles, swivels and swivel shackles.

5.1.3 Studless link chain is normally to be deployed only once, being intended for long-term permanent mooring systems with pre-determined design life.

5.2 Chain grades

5.2.1 Depending on the nominal tensile strength of the steels used for manufacture, chains are subdivided into five grades, namely R3, R3S, R4, R4S and R5.

5.2.2 Manufacturers propriety specifications for R4S and R5 may vary subject to design conditions and acceptance of IRS.

5.2.3 Each Grade is to be individually approved. Approval for a higher grade does not constitute approval of a lower grade.

5.3 Approval of chain manufacturers

5.3.1 Offshore mooring chain are to be manufactured only by works approved by IRS. For this purpose approval tests are to be carried out, the scope of which is to include proof and breaking load tests, measurements and mechanical tests including fracture mechanics tests.

5.3.2 Manufacturers are to submit for review and approval the sequence of all operations from receiving inspection of raw materials to the shipment of finished products along with details of the following manufacturing processes:

a) bar heating and bending including the method, temperatures, temperature control and recording;

b) flash welding including current, force, time and dimensional variables as well as control and recording of parameters;

c) flash removal including method and inspection;

d) stud insertion method for stud link chain;

e) heat treatment including furnace types, means of specifying, controlling and recording of temperature and chain speed and allowable limits, quenching bath and agitation, cooling method after exit;

f) proof and break loading including method/machinery, means of horizontal support (if applicable), method of measurement and recording;

g) non-destructive examination procedures.

h) the manufacturer's surface quality requirement of mooring components.

5.3.3 For initial approval CTOD (Crack Tip Opening Displacement) tests are to be carried out on the particular mooring grade of material. CTOD tests are to be conducted in accordance with a recognized standard such as BS 7448 Parts 1 and 2. The CTOD test piece is to be a standard 2 x 1 single edge notched bend piece, test location as shown in Fig.5.3.1. The minimum test piece size is to be 50 x 25 [mm] for chain diameter less than 120 [mm] and 80 x 40 [mm] for diameter 120 [mm] and above. CTOD specimens are to be taken from both the side of the link containing the weld and from the opposite side. Three links are to be selected for testing, i.e, a total of six CTOD specimens. The tests are to be taken at minus 20°C and meet the minimum values indicated below:

Chain Type	R3 [mm]		R3S [mm]		R4 [mm]		R4S and R5 [mm]	
	BM	WM	BM	WM	BM	WM	BM	WM
Stud link	0.20	0.10	0.22	0.11	0.24	0.12	0.26	0.13
Studless	0.20	0.14	0.22	0.15	0.24	0.16	0.26	0.17
Note : BM : Base metal WM : Welded metal								

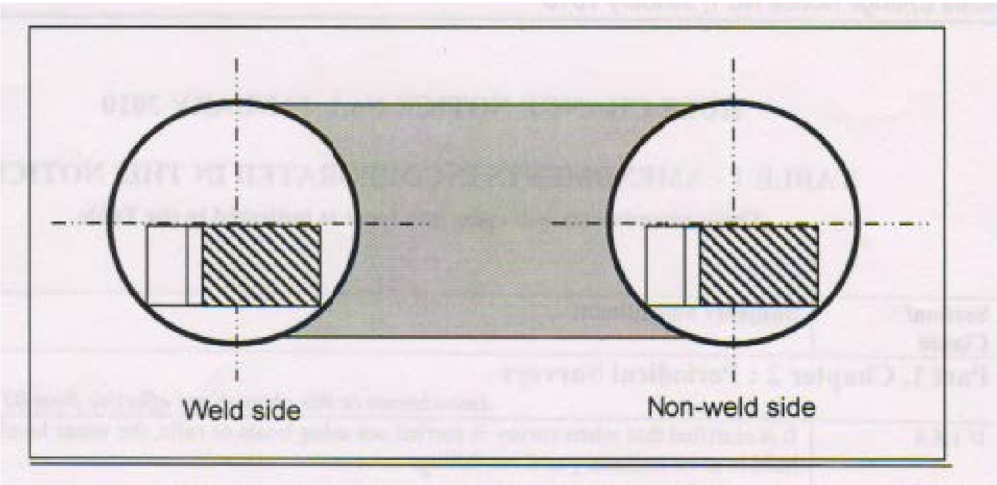


Fig.5.3.1 : Location of CTOD test specimens

5.3.4 Calibration of furnaces is to be verified by measurement and recording of a calibration test piece with dimensions equivalent to the maximum size of link manufactured. Thermocouples are to be placed both on the surface and in a drilled hole located at the mid thickness position of the calibration block.

5.3.5 For R4S and R5 chain and accessories, prior to approval, the manufacturer is to have undertaken experimental tests or have relevant supporting data to develop the chain and accessory material. The tests and data may include: fatigue tests, hot ductility tests (no internal flaws are to develop whilst bending in the link forming temperature range), welding parameter research, heat treatment study, strain age resistance, temper embrittlement study, stress corrosion cracking (SCC) data and hydrogen embrittlement (HE) study, using slow strain test pieces in hydrated environments. Reports indicating the results of experimental tests are to be submitted.

5.4 Approval of quality system at chain and accessory manufacturers

5.4.1 Chain and accessory manufacturers are to have a documented and effective quality system approved by IRS. The provision of such a quality system is required in addition to, and not in lieu of, the witnessing of tests by a Surveyor as specified in 5.7 to 5.14.

5.5 Approval of steel mills - rolled bar

5.5.1 Bar material intended for chain and accessories are to be manufactured only by works approved by IRS. The approval is limited to a nominated supplier of bar material. If a chain manufacturer wishes to use material from a number of suppliers, separate approval tests must be carried out for each supplier.

Approval will be given only after successful testing of the completed chain. The approval will normally be limited upto the maximum diameter equal to that of the chain diameter tested. The rolling reduction ratio is to be recorded and is to be at least 5:1. The rolling reduction ratio used in production can be higher, but should not be lower than that qualified.

5.5.2 The bar manufacturer is to submit a specification of the chemical composition of the bar material, which must be approved by IRS and by the chain manufacturer.

For Grade R4, R4S and R5 chain the steel is to contain a minimum of 0.20 per cent molybdenum.

5.5.3 A heat treatment sensitivity study simulating chain production conditions is to be applied in order to verify mechanical properties and establish limits for temperature and time combinations. All test details and results are to be submitted to IRS.

5.5.4 The bar manufacturer is to provide evidence that the manufacturing process produces material that is resistant to strain ageing, temper embrittlement and for R3S, R4, R4S and R5, hydrogen embrittlement. All test details and results are to be submitted to IRS.

5.6 Approval of forge shops and foundries - accessories

5.6.1 Forge shops and foundries intending to supply finished or semi-finished accessories are to be approved by IRS. A description of manufacturing processes and process controls is to be submitted to IRS. The scope of approval is to be approved by IRS. The approval is to be limited to a nominated supplier of forged or cast material. If an accessory manufacturer wishes to use material from a number of suppliers, a separate approval must be carried out for each supplier.

5.6.2 Approval will be given only after successful testing of the completed accessory. The approval will normally be limited to the type of accessory and the designated mooring grade of material upto the maximum diameter or thickness equal to that of the completed accessory used for qualification. Qualification of accessory pins to maximum diameters is also required. Individual accessories of complex geometries will be specially considered.

5.6.3 For forgings – The forging reduction ratio, used in the qualification tests, from cast ingot / slab to forged component is to be recorded. The forging reduction ratio used in production can be higher, but should not be lower than that qualified.

5.6.4 The forge shop or foundry is to submit a specification of chemical composition of the forged or cast material, which must be approved by IRS. For Grade R4, R4S and R5 chain the steel should contain a minimum of 0.20 per cent molybdenum.

5.6.5 Forges and foundries are to provide evidence that the manufacturing process produces material that is resistant to strain ageing, temper embrittlement and for R4S and R5 grades, hydrogen embrittlement. A heat treatment sensitivity study simulating accessory production conditions shall be applied in order to verify mechanical properties and establish limits for temperature and time combinations. (Cooling after tempering shall be appropriate to avoid temper embrittlement). All test details and results are to be submitted to IRS.

5.6.6 For initial approval CTOD tests are to be carried out on the particular mooring grade of material. Three CTOD tests are to be tested in accordance with a recognized standard such as BS 7448 Parts 1 and 2. The CTOD test piece is to be a standard 2 x 1 single edge notched bend specimen taken from the quarter thickness location. The minimum test piece size shall be 50 x 25 [mm] for chain diameters less than 120 [mm] and 80 x 40 [mm] for diameters 120 [mm] and above. The tests are to be taken at minus 20°C and the results submitted for review.

5.6.7 Calibration of furnaces shall be verified by measurement and recording of a calibration test piece with dimensions equivalent to the maximum size of link manufactured. Thermocouples are to be placed both on the surface and in a drilled hole located to the mid thickness position of the calibration block.

5.6.8 For R4S and R5 refer to additional requirements in 5.3.5.

5.7 Rolled steel bars

5.7.1 Steel manufacture

5.7.1.1 The steels are to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steels are to be killed and fine grain treated. The austenitic grain size is to be 6 or finer in accordance with ASTM E112.

5.7.1.2 Steel for bars intended for R4S and R5 chain is to be vacuum degassed.

5.7.1.3 For R4S and R5 the following information is to be supplied by the bar manufacturer to the mooring chain manufacturer and the results included in the chain documentation:

a) Each heat is to be examined for non-metallic inclusions. The level of micro inclusions is to be quantified and assessed to be sure inclusion levels are acceptable for the final product.

b) A sample from each heat is to be macro etched according to ASTM E381 or equivalent to be sure there is no injurious segregation or porosity.

c) Jominy hardenability data, according to ASTM A255, or equivalent, is to be supplied with each heat.

5.7.2 Chemical composition

For acceptance tests, the chemical composition of ladle samples of each heat is to be determined by the bar manufacturer and is to comply with the approved specification (see 5.5.2).

5.7.3 Mechanical tests

.1 Bars of the same nominal diameter are to be presented for test in batches of 50 tonnes or fraction thereof from the same heat. Test specimens are to be taken from material heat treated in the same manner as intended for the finished chain.

.2 Each heat of Grade R3S, R4, R4S and R5 steel bars is to be tested for hydrogen embrittlement. In case of continuous casting, test samples representing both the beginning and the end of the charge are to be taken. In case of ingot casting, test samples representing two different ingots are to be taken.

a) Two tensile test specimens are to be taken from the central region of bar material which has been subjected to the heat treatment cycle intended to be used in production. The specimens are to preferably have a diameter of 20 mm, alternatively 14 mm. One specimen is to be tested within max. 3 hours (1 1/2 hours for 14 mm diameter specimen) after machining. Where this is not possible, the specimen is to be cooled to -60°C immediately after machining and kept at that temperature for a period of maximum 5 days.

   The second specimen is to be tested after baking at 250°C for 4 hours (2 hours for 14 mm diameter specimen).

b) A slow strain rate < 0.0003 per second is to be used during the entire test, until fracture occurs. (This is approx. 10 minutes for a 20 mm diameter specimen).

c) Tensile strength, elongation and reduction of area are to be reported. The requirement for the test is:

$$\frac{Z_1}{Z_2} \geq 0.85$$

where,

Z_1 = Reduction of area without baking

Z_2 = Reduction of area after baking

d) If the requirement of $Z_1/Z_2 \geq 0.85$ is not achieved, the bar material may be subjected to a hydrogen degassing treatment after agreement with the Surveyor(s). New tests are to be performed after degassing.

.3 For all grades, one tensile and three Charpy V-notch specimens are to be taken from each sample selected. The test specimens are to be taken at approximately one-third radius below the surface, as shown in Sec. 2, Fig.2.4.1. The results of all tests are to be in accordance with the appropriate requirements of Table 5.7.1.

.4 If the tensile test requirements are not achieved, a retest of two further specimens selected from the same sample will be permissible.
Failure to meet the specified requirements of either or both additional tests will result in rejection of the batch represented unless it can be clearly attributable to improper simulation of the heat treatment.

.5 If the impact test requirements are not achieved, a retest of three further specimens selected from the same sample will be permissible. The results are to be added to those previously obtained to form a new average. The new average is to comply with the requirements. No more than two individual results are to be lower than the required average and no more than one result is to be below 70 per cent of the specified average value.
Failure to meet the requirements will result in rejection of the batch represented. Where the failure can be clearly attributable to improper simulation of the heat treatment, new tests may be permitted at the discretion of the Surveyor.

5.7.4 Dimensional tolerances

The diameter and roundness are to be within the tolerances specified in Sec. 2, Table 2.4.3, unless otherwise agreed.

5.7.5 Non-destructive examination and repair

a) Non-destructive examination is to be performed in accordance with recognized standards. Non-destructive examination procedures, together with rejection / acceptance criteria are to be submitted to IRS.

b) Non-destructive examination operators are to be appropriately qualified (to a minimum level II in accordance with a recognized standard such as ISO 9712, SNT-TC-1A, EN 473 or ASNT Central Certification Program) in the method of non-destructive examination.

c) 100 percent of bar material intended for either chain or fittings is to be subjected to ultrasonic examination at an appropriate stage of the manufacture. The bars are to be free of pipe, cracks and flakes.

d) 100 percent of the bar material is to be examined by magnetic particle or eddy current methods. The bars are to be free of injurious surface imperfections such as seams, laps and rolled-in mill scale. Provided that their depth is not greater than 1 per cent of the bar diameter, longitudinal discontinuities may be removed by grinding and blending to a smooth contour.

e) The frequency of NDE may be reduced at the discretion of the Surveyor provided it is verified by statistical means that the required quality is consistently achieved.

5.7.6 Marking

Each bar is to be stamped with the steel grade designation and the charge number (or a code indicating the charge number) on one of the end surfaces. Other marking methods may be accepted subject to agreement.

Table 5.7.1 : Mechanical properties of offshore mooring chain and accessories

Grade	Yield stress [N/mm^2] min. (Note 1)	Tensile strength [N/mm^2] min. (Note 1)	Elonga-tion % min.	Reduc-tion of area % min. (Note 3)	Charpy V-notch impact test		
					Test temp. °C (Note 2)	Average energy J min.	Average energy flash weld J min.
R3	410	690	17	50	0 -20	60 40	50 30
R3S	490	770	15	50	0 -20	65 45	53 33
R4	580	860	12	50	-20	50	36
R4S (Note 4)	700	960	12	50	-20	56	40
R5 (Note 4)	760	1000	12	50	-20	58	42

Notes:

1 Aim value of yield to tensile ratio: 0.92 max.

2 At the option of IRS the impact test of Grade R3 and R3S may be carried out at either 0°C or minus 20°C.

3 Reduction of area of cast steel is to be for Grades R3 and R3S: min. 40%, for R4, R4S and R5 : min. 35% (see 5.9.4).

4 Aim maximum hardness for R4S is HB330 and R5, HB340.

5.8 Forged steel

5.8.1 Manufacture

5.8.1.1 Forged steels used for the manufacture of accessories are to be in compliance with approved specifications and the submitted test reports approved by IRS. Steel is to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steel is to be killed and fine grain treated. The austenitic grain size is to be 6 or finer in accordance with ASTM E112.

5.8.1.2 Steel for forgings intended for R4S and R5 chain is to be vacuum degassed.

5.8.1.3 For steel intended for R4S and R5 accessories the following information is to be supplied by the steel manufacturer to the mooring accessory manufacturer and the results included in the accessory documentation:

a) Each heat is to be examined for non-metallic inclusions. The level of micro inclusions is to be quantified and assessed, to be sure inclusion levels are acceptable for the final product.

b) A sample from each heat is to be macroetched according to ASTM E381 or equivalent, to be sure there is no injurious segregation or porosity.

c) Jominy hardenability data, according to ASTM A255 or equivalent, is to be supplied with each heat.

5.8.2 Chemical composition

For acceptance tests, the chemical composition of ladle samples of each heat is to be determined by the bar manufacturer and is to comply with the approved specification (see 5.5.2).

5.8.3 Heat treatment

Finished forgings are to be properly heat treated in compliance with specifications approved by IRS.

5.8.4 Mechanical properties

The forgings are to comply with the mechanical properties given in Table 5.7.1, when properly heat treated.

5.8.5 Mechanical tests

For test sampling, forgings of similar dimensions (diameters do not differ by more than 25 mm) originating from the same heat treatment charge and the same heat of steel are to be combined into one test unit. From each test unit one tensile and three impact test specimens are to be taken and tested. For the location of the test specimens see Sec. 2, Fig.2.4.1.

5.8.6 Ultrasonic examination

5.8.6.1 Non-destructive examination is to be performed in accordance with recognized standards and the non-destructive examination procedures, together with rejection / acceptance criteria are to be submitted to IRS.

5.8.6.2 Non-destructive examination operators are to be appropriately qualified (to a minimum level II in accordance with a recognized standard such as ISO 9712, SNT-TC-1A, EN 473 or ASNT Central Certification Program) in the method of non-destructive examination.

5.8.6.3 The forgings are to be subjected to 100 percent ultrasonic examination at an appropriate stage of manufacture and in compliance with the standard approved by IRS.

5.8.7 Marking

Marking is to be similar to that specified in 5.7.6.

5.9 Cast steel

5.9.1 Manufacture

5.9.1.1 Cast steels used for the manufacture of accessories are to be in compliance with approved specifications and the submitted test reports approved by IRS. Steel is to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steel is to be killed and fine grain treated. The austenitic grain size is to be 6 or finer in accordance with ASTM E112.

5.9.1.2 Steel for castings intended for R4S and R5 accessories is to be vacuum degassed.

5.9.1.3 For steel intended for R4S and R5 accessories the following information is to be obtained and the results included in the accessory documentation:

a) Each heat is to be examined for non-metallic inclusions. The level of micro inclusions is to be quantified and assessed to be sure inclusion levels are acceptable for the final product.

b) A sample from each heat is to be macro etched according to ASTM E381 or equivalent to be sure there is no injurious segregation or porosity.

c) Jominy hardenability data, according to ASTM A255, or equivalent is to be supplied with each heat.

5.9.2 Chemical composition

For acceptance tests, the chemical composition of ladle samples of each heat is to be determined by the bar manufacturer and is to comply with the approved specification (see 5.5.2).

5.9.3 Heat treatment

All castings are to be properly heat treated in compliance with specifications approved by IRS.

5.9.4 Mechanical properties

The castings are to comply with the mechanical properties given in Table 5.7.1. The requirement for reduction of area is, however, reduced to 40 per cent for grades R3 and R3S and 35 per cent for grade R4, R4S and R5.

5.9.5 Mechanical tests

For test sampling, castings of similar dimensions originating from the same heat treatment charge and the same heat of steel are to be combined into one test unit. From each test unit one tensile and three impact test specimens are to be taken and tested. For the location of the test specimens see Sec. 2, Fig.2.4.1.

5.9.6 Ultrasonic examination

5.9.6.1 Non-destructive examination is to be performed in accordance with recognized standards and the non-destructive examination procedures, together with rejection / acceptance criteria are to be submitted to IRS.

5.9.6.2 Non-destructive examination operators are to be appropriately qualified (to a minimum level II in accordance with a recognized standard such as ISO 9712, SNT-TC-1A, EN 473 or ASNT Central Certification Program) in the method of non-destructive examination.

5.9.6.3 The castings are to be subjected to 100 percent ultrasonic examination in compliance with the standard approved by IRS.

5.9.7 Marking

Marking is to be similar to that specified in 5.7.6.

5.10 Materials for studs

5.10.1 The studs intended for stud link chain cable are to be made of steel corresponding to that of the chain or in compliance with specifications approved by IRS. In general, the carbon content is not to exceed 0.25 per cent if the studs are to be welded in place.

5.11 Design

5.11.1 Plans with design calculations, giving detailed design of chain and accessories made by or supplied through the chain manufacturer are to be submitted for approval. Typical designs are given in ISO 1704 (see Sec. 2, Fig.2.3.1 to 2.3.6). For studless chain the shape and proportions are to comply with the requirements of this section. Other studless proportions are to be specially approved. It should be considered that new or non-standard designs of chain, shackles or fittings, may require a fatigue analysis and possible performance, fatigue or corrosion fatigue testing.

5.11.2 In addition for stud link chain, plans showing the detailed design of the stud are to be submitted for information. The stud is to give an impression in the chain link which is sufficiently deep to secure the position of the stud, but the combined effect of shape and depth of the impression is to be such as not to cause any harmful notch effect or stress concentration in the chain link.

5.11.3 Machining of Kenter shackles is to result in fillet radius of minimum 3 per cent of nominal diameter.

5.12 Chain cable manufacturing process

5.12.1 General

Offshore mooring chains are to be manufactured in continuous lengths by flash butt welding and are to be heat treated in a continuous furnace; batch heat treatment is not permitted. The use of joining shackles to replace defective links is subject to the written approval of the end purchaser in terms of the number and type permitted. The use of connecting common links is restricted to 3 links in each 100 m of chain.

5.12.2 Manufacturing process records

Records of bar heating, flash welding and heat treatment are to be made available for inspection by the Surveyor.

5.12.3 Bar heating

a) For electric resistance heating, the heating phase is to be controlled by an optical heat sensor. The controller is to be checked at least once every 8 hours and the records are to be maintained.

b) For furnace heating, the heat is to be controlled and the temperature continuously recorded using thermocouples in close proximity to the bars. The controls are to be checked at least once every 8 hours and the records are to be maintained.

5.12.4 Flash welding

The following welding parameters are to be controlled during welding of each link:

a) Platen motion;

b) Current as a function of time;

c) Hydraulic pressure.

The controls are to be checked at least every 4 hours and records are to be maintained.

5.12.5 Heat treatment

a) Chain is to be austenitized, above the upper transformation temperature, at a combination of temperature and time within the limits established.

b) When applicable, chain is to be tempered at a combination of temperature and time within the limits established. Cooling after tempering is to be appropriate to avoid temper embrittlement.

c) Temperature and time or temperature and chain speed are to be controlled and continuously recorded.

5.12.6 Mechanical properties

The mechanical properties of finished chain and accessories are to be in accordance with Table 5.7.1. For the location of test specimens see Sec. 2, Fig.2.4.1.

5.12.7 Proof and breaking test loads

Chains and accessories are to withstand the proof and break test loads given in Table 5.12.1.

Table 5.12.1 : Formulae for proof and break test loads, weight and length over 5 links

Grade Type	Proof load [kN]	Break load [kN]
Grade R3 Stud Link	$0.0148\ d^2\ (44 - 0.08d)$	$0.0223\ d^2\ (44 - 0.08d)$
Grade R3S Stud Link	$0.0180\ d^2\ (44 - 0.08d)$	$0.0249\ d^2\ (44 - 0.08d)$
Grade R4 Stud Link	$0.0216\ d^2\ (44 - 0.08d)$	$0.0274\ d^2\ (44 - 0.08d)$
Grade R4S Stud Link	$0.0240\ d^2\ (44 - 0.08d)$	$0.0304\ d^2\ (44 - 0.08d)$
Grade R5 Stud Link	$0.0251\ d^2\ (44 - 0.08d)$	$0.0320\ d^2\ (44 - 0.08d)$
Grade R3 Studless	$0.0148\ d^2\ (44 - 0.08d)$	$0.0223\ d^2\ (44 - 0.08d)$
Grade R3S Studless	$0.0174\ d^2\ (44 - 0.08d)$	$0.0249\ d^2\ (44 - 0.08d)$
Grade R4 Studless	$0.0192\ d^2\ (44 - 0.08d)$	$0.0274\ d^2\ (44 - 0.08d)$
Grade R4S Studless	$0.0213\ d^2\ (44 - 0.08d)$	$0.0304\ d^2\ (44 - 0.08d)$
Grade R5 Studless	$0.0223\ d^2\ (44 - 0.08d)$	$0.0320\ d^2\ (44 - 0.08d)$
Chain Weight [kg/m]	Stud link = $0.0219\ d^2$	
Chain Weight [kg/m]	Studless chain weight calculations for each design are to be submitted	
Pitch Length :	Five link measure	
Minimum	22d	
Maximum	22.55d	

5.12.8 Freedom from defects

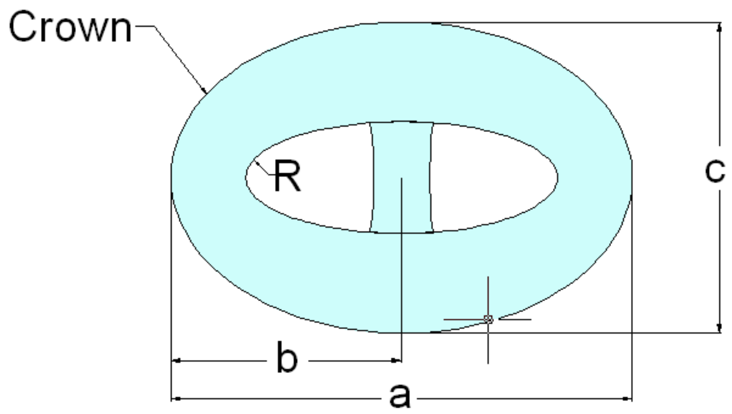
All chains are to have a workmanlike finish consistent with the method of manufacture and be free from defects. Each link is to be examined in accordance with 5.15.5 using approved procedures.

5.12.9 Dimensions and dimensional tolerances

The form and proportion of links and accessories are to be in accordance with the approved design. The tolerances given in Sec. 2, Cl. 2.3 are applicable, in general.

In addition, the tolerances for stud link and studless common links are to be measured in accordance with Fig.5.12.9a) and b).

a) **Stud Link** – The internal link radii (R) and external radii should be uniform

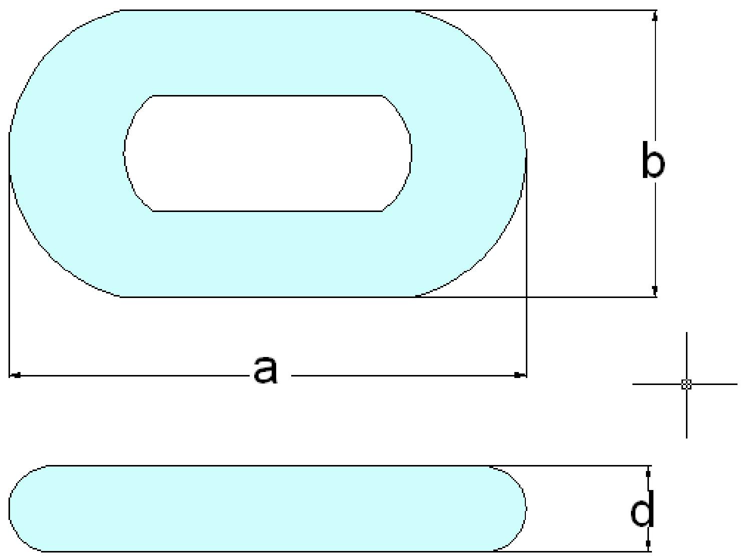


Designation [1)]	**Description**	**Nominal Dimension of the Link**	**Minus Tolerance**	**Plus Tolerance**
a	Link length	6d	0.15d	0.15d
b	Link half length	a*/2	0.1d	0.1d
c	Link width	3.6d	0.09d	0.09d
e	Stud angular misalignment	0 degrees	4 degrees	4 degrees
R	Inner radius	0.65d	0	----

Notes : 1 Dimension designation is shown in above figure
d = Nominal diameter of chain, (Refer Fig.2.3.1) a* = Actual link length

Fig.5.12.9a) : Stud Link common link, proportions dimensions and tolerances

b) **Studless** – The internal link radii (R) and external radii should be uniform.



Designation [1)]	Description	Nominal Dimension of the Link	Minus Tolerance	Plus Tolerance
a	Link length	6d	0.15d	0.15d
b	Link width	3.35d	0.09d	0.09d
R	Inner radius	0.60d	0	----

Notes : 1 Dimension designation is shown in above figure
d = Nominal diameter of chain
2 Other dimension ratios are subject to special approval.

Fig.5.12.9b) : Stud less common link, proportions dimensions and tolerances

5.12.10 Welding of studs

a) A welded stud may be accepted for grade R3 and R3S chains. Welding of studs in grade R4 chain is not permitted unless specially approved.

b) Where studs are welded into the links, the welding is to be completed before the chain is heat treated.

c) The stud ends must be a good fit inside the link and the weld is to be confined to the stud end opposite to the flash butt weld. The full periphery of the stud end is to be welded unless otherwise approved.

d) Welding of studs at both ends is not permitted unless specially approved.

e) The welds are to be made by qualified welders using an approved procedure and low-hydrogen approved consumables.

f) The size of the fillet weld is, as a minimum, to be as per API Specification 2F.

g) The welds are to be of good quality and free from defects such as cracks, lack of fusion, gross porosity and undercuts exceeding 1 mm.

h) All stud welds are to be visually examined. At least 10 per cent of all stud welds within each length of chain are to be examined by dye penetrant or magnetic particles after proof load testing. If cracks or lack of fusion are found, all stud welds in that length are to be examined.

5.12.11 Connecting common links (splice links)

.1 Single links to substitute for test links or defective links without the necessity for re-heat treatment of the whole length are to be made in accordance with an approved procedure. Separate approvals are required for each grade of chain and the tests are to be made on the maximum size of chain for which approval is sought.

.2 Manufacture and heat treatment of connecting common link is not to affect the properties of the adjoining links. The temperature reached by these links is nowhere to exceed 250°C.

.3 Each link is to be subjected to the appropriate proof load and non-destructive examination as detailed in Table 5.12.1 and 5.13.5 respectively. A second link is to be made identical to the connecting common link; the link is to be tested and inspected as per 5.13.4 and 5.14.5.

.4 Each connecting common link is to be marked either on the stud for stud link chain, or on the outer straight length on the side opposite the flash butt weld for studless chain. This marking is to be in accordance with 5.13.7 plus a unique number for the link. The adjoining links are also to be marked on the studs or straight length as above.

5.13 Testing and inspection of finished chain

5.13.1 General

a) This section applies to but is not limited to finished chain cable such as common stud and studless links, end links, enlarged end links and connecting common links (splice links).

b) All chains are to be subjected to proof load tests, sample break load tests and sample mechanical tests after final heat treatment in the presence of Surveyor. Where the manufacturer has a procedure to record proof loads and the Surveyor is satisfied with the adequacy of the recording system, he may not witness all proof load tests. The Surveyor is to satisfy himself that the testing machines are calibrated and maintained in a satisfactory condition.

c) Prior to testing and inspection chains are to be free from scale, paint or other coating. The chains are to be sand- or shot blasted to meet this requirement.

5.13.2 Proof and break load tests

a) The entire length of chain is to withstand the proof load specified in Table 5.12.1 without fracture and without crack in the flash weld. The load applied is not to exceed the proof load by more than 10 per cent when stretching the chain. Where plastic straining is used to set studs, the applied load is not to be greater than that qualified in approval tests.

b) A break-test specimen consisting of at least 3 links is to be either taken from the chain or produced at the same time and in the same manner as the chain. The test frequency is to be based on tests at sampling intervals according to Table 5.13.1 provided that every cast is represented. Each specimen is to be capable of withstanding the break load specified without fracture and without crack in the flash weld. It will be considered acceptable if the specimen is loaded to the specified value and maintained at that load for 30 seconds.

c) For chain diameters over 100 [mm], alternative break-test proposals to the above break-test will be considered whereby a one link specimen is used. Alternatives are to be approved by IRS. Every heat is to be represented, the test frequency is to be in accordance with Table 5.13.1 and it is to be demonstrated and proven that the alternative test represents an equivalent load application to the three link test.

d) If the loading capacity of the testing machine is insufficient, another equivalent method will be considered by IRS.

Table 5.13.1 : Frequency of break and mechanical tests

Nominal chain diameter (mm)	Maximum sampling interval (m)
Min - 48	91
49 - 60	110
61 - 73	131
74 - 85	152
86 - 98	175
99 - 111	198
112 - 124	222
125 - 137	250
138 - 149	274
150 - 162	297
163 - 175	322
176 – 186	346
187 – 199	370
200 - 210	395

5.13.3 Dimensions and dimensional tolerances

After proof load testing, measurements are to be taken on at least 5 per cent of the links in accordance with 5.12.9.

The entire chain is to be checked for the length, five links at a time. By the five link check the first five links are to be measured. In the next set of five links, at least two links from the previous five links set are to be included. This procedure is to be followed for the entire chain length. The measurements are to be taken preferably while the chain is loaded to 5 - 10 per cent of the minimum proof load. The links held in the end blocks may be excluded from this measurement.

5.13.4 Mechanical tests

a) Links of samples detached from finished, heat treated chain are to be sectioned for determination of mechanical properties. A test unit is to consist of one tensile and nine impact specimens. The tensile specimen is to be taken in the side opposite the flash weld. Three impact specimens are to be taken across the flash weld with the notch centered in the middle. Three impact specimens are to be taken across the unwelded side and three impact specimens are to be taken from the bend region.

b) The test frequency is to be based on tests at sampling intervals according to Table 5.13.1 provided that every cast is represented. Mechanical properties are to be as specified in Table 5.7.1.

c) The frequency of impact testing in the bend may be reduced at the discretion of the Surveyor provided it is verified by statistical means that the required toughness is consistently achieved.

5.13.5 Non-destructive examination

a) After proof load testing, all surfaces of every link are to be visually examined. Burrs, irregularities and rough edges are to be contour ground. Links are to be free from mill defects, surface cracks, dents and cuts, especially in the vicinity where gripped by clamping dies during flash welding. Studs are to be securely fastened. Chain is to be positioned in order to have good access to all surfaces.

b) Testing is to be performed in accordance with a recognized standard and the procedures, together with acceptance / rejection criteria are to be submitted to IRS for review. Operators are to be appropriately qualified, in the method of inspection, to at least level II in accordance with a recognized standard such as ISO 9712, SNT-TC-1A, EN 473 or ASNT Central Certification Program.

c) Magnetic particle testing is to be employed to examine the flash welded area including the area gripped by the clamping dies. Approved procedures and equipment are to be used. Every link is to be examined. Additionally, 10% of links are to be tested on all accessible surfaces.

Link surface at the flash weld is to be free from cracks, lack of fusion and gross porosity.

d) Ultrasonic testing is to be employed to examine the flash weld fusion. Approved procedures and equipment are to be used. On-site calibration standards for chain configurations are to be approved.

Every link is to be examined.

The flash weld is to be free from defects causing ultrasonic back reflections equal to or greater than the calibration standard.

e) If link diameter, length, width and stud alignment do not conform to the required dimensions, these are to be compared to the dimensions of 40 more links; 20 on each side of the affected link. If a single particular dimension fails to meet the required dimensional tolerance in more than 2 of the sample links, all links are to be examined and requirements of 5.13.6(b) are applied.

5.13.6 Retest, rejection and repair criteria

a) If the length over 5 links is short, the chain may be stretched by loading above the proof test load specified provided that the applied load is not greater than that approved and that only random lengths of the chain need stretching. If the length exceeds the specified tolerance, the overlength chain links are to be cut out and the requirements of 5.13.6(b) applied.

b) If single links are found to be defective or to not meet other applicable requirements, defective links may be cut out and a connecting common link inserted in their place. The individual heat treatment and inspection procedure of connecting common links is subject to the approval of the Surveyor. Other methods of repair are subject to approval of the Surveyor and the end purchaser.

c) If a crack, cut or defect in the flash weld is found by visual or magnetic particle examination, it is to be ground down no more than 5 per cent of the link diameter in depth and streamlined to avoid any sharp contours. However the final dimensions are to conform to the agreed standard.

d) If indications of interior flash weld defects in reference to the accepted calibration standards are detected during ultrasonic examination, requirements of 5.13.6(b) are applied.

f) If a break load test fails, a thorough examination is to be carried out to identify the cause of failure. Two additional break test specimens representing the same sampling length of chain are to be subjected to the break load test. Based upon satisfactory results of the additional tests and the results of the failure investigation, it will be decided what lengths of chain can be accepted. Failure of either or both additional tests will result in rejection of the sampling length of chain represented and requirements of 5.13.6(b) are applied.

g) If a link fails during proof load testing, a thorough examination is to be carried out to identify the probable cause of failure of the proof load test. In the event that two or more links in the proof loaded length fail, that length is to be rejected.

The above mentioned failure investigation is to especially aim at ascertaining the presence in other lengths of factors or conditions thought to be causal to failure.

In addition, a break test specimen is to be taken from each side of the one failed link and subjected to the breaking test. Based upon satisfactory results of both break tests and the results of the failure investigation, it will be decided what length of chain can be considered for acceptance. Failure of either or both breaking tests will result in rejection of the same proof loaded length.

Replacement of defective links is to be in accordance with the requirements of 5.13.6(b).

h) If the tensile test fails to meet the requirements, a retest of two further specimens selected from the same sample will be permissible. Failure to meet the specified requirements of either or both additional tests will result in rejection of the sampling length of chain represented and requirements of 5.13.6(b) are applied.

i) If the impact test requirements are not achieved, a retest of three further specimens selected from the same sample will be permissible. The results are to be added to those previously obtained to form a new average. The new average is to comply with the requirements. No more than two individual results are to be lower than the required average and no more than one result is to be below 70 per cent of the specified average value.

Failure to meet the requirements will result in rejection of the sampling length represented and requirements of 5.13.6(b) are applied.

5.13.7 Marking

.1 The chain is to be marked at the following places:

- At each end.
- At intervals not exceeding 100 m.
- On connecting common links.
- On links next to shackles or connecting common links.

All marked links are to be stated on the certificate, and the marking is to make it possible to recognize leading and tail end of the chain. In addition to the above required marking, the first and last common link of each individual charge used in the continuous length is to be traceable and adequately marked.

The marking is to be permanent and legible throughout the expected lifetime of the chain.

.2 The chain is to be marked on the studs as follows:

- Chain grade
- Certificate No.
- IRS stamp

The Certificate number may be exchanged against an abbreviation or equivalent, in which case the details are to be stated in the certificate.

The chain certificate will contain information on number and location of connecting common links. The certificate number and replacement link number may be exchanged against an abbreviation or equivalent, in which case, the details are to be stated in the certificate.

5.13.8 Documentation

a) A complete Chain Inspection and Testing Report in booklet form is to be provided by the chain manufacturer for each continuous chain length. This booklet is to include all dimensional checks, test and inspection reports, NDT reports, process records, photographs as well as any nonconformity, corrective action and repair work.

b) Individual certificates are to be issued for each continuous single length of chain.

c) All accompanying documents, appendices and reports are to carry reference to the original certificate number.

d) The manufacturer will be responsible for storing, in a safe and retrievable manner, all documentation produced for a period of at least 10 years.

5.14 Testing and inspection of accessories

5.14.1 General

a) Requirements in 5.14 apply to but is not limited to mooring equipment accessories such as detachable connecting links (shackles), detachable connecting plates (triplates), end shackles, swivels and swivel shackles.

b) Prior to test and inspection the chain accessories are to be free from scale, paint or other coating.

c) All accessories are to be subjected to proof load tests sample, break load tests and sample mechanical tests after final heat treatment in the presence of a Surveyor. Where the manufacturer has a procedure to record proof loads and the Surveyor is satisfied with the adequacy of the recording system, he may not witness all proof load tests. The Surveyor is to satisfy himself that the testing machines are calibrated and maintained in a satisfactory condition.

5.14.2 Proof and break load tests

a) All accessories are to be subjected to the proof load specified for the corresponding stud link chain.

b) Chain accessories are to be tested to the break test loads prescribed for the grade and size of chain for which they are intended. At least one accessory out of every 25 accessories is to be tested.

For individually produced accessories or accessories produced in small batches (less than 5), alternative testing will be subject to special consideration. A batch is defined as accessories that originate from the same heat treatment charge and the same heat of steel. Accessories which have been subjected to a break test are to be scrapped, in general. However, where the accessories are of increased dimensions or alternatively a material with higher strength characteristics is used, they may be included in the outfit at the discretion of IRS provided that:

i) the accessories are successfully tested at the prescribed breaking load appropriate to the chain for which they are intended, and

ii) it is verified by procedure tests that such accessories are so designed that the breaking strength is not less than 1.4 times the prescribed breaking load of the chain for which they are intended.

5.14.3 Dimensions and dimensional tolerances

a) After proof load testing, at least one accessory (of the same type, size and nominal strength) out of 25 is to be checked for dimensions in accordance with 5.12.9. The manufacturer is to provide an adequate evidence indicating compliance with the purchaser's requirements.

b) The following tolerances are applicable to accessories:

- Nominal diameter : +5 percent, -0 percent
- Other dimensions : ± 2 ½ percent.

These tolerances do not apply to machined surfaces.

5.14.4 Mechanical tests

a) Accessories are to be subjected to mechanical testing as described in 5.8 and 5.9. Mechanical tests are to be taken from proof loaded full size accessories that have been heat treated with the production accessories they represent. The use of separate representative coupons is not permitted except as indicated in d) below.

b) Test location of forged shackles. Forged shackle bodies and forged Kenter shackles are to have a set of three impact tests and a tensile test taken from the crown of the shackle. Tensile tests on smaller diameter shackles can be taken from the straight part of the shackle, where the geometry does not permit a tensile specimen from the crown. The tensile properties and impact values are to meet the requirements of Table 5.7.1 in the locations specified in Fig.2.4.1 of Section 2 with the Charpy pieces on the outside radius.

c) The locations of mechanical tests of cast shackles and cast Kenter shackles can be taken from the straight part of the accessory. The tensile properties and impact values are to meet the requirements of Table 5.7.1 in the locations specified in Fig.2.4.1 of Section 2.

d) The locations of mechanical tests of other accessories with complex geometries are to be agreed with IRS.

e) For individually produced accessories or accessories produced in small batches, (less than 5), alternative testing can be proposed to IRS. Each proposal for alternative testing is to be detailed by the manufacturer in a written procedure.

f) A batch is defined as accessories that originate from the same heat treatment charge and the same heat of steel.

g) Mechanical tests of pins are to be taken as per Fig.2.4.1 of Section 2 from the mid length of a sacrificial pin of the same diameter as the final pin. For oval pins the diameter taken is to represent the smaller dimension. Mechanical tests may be taken from an extended pin of the same diameter as the final pin that incorporates a test prolongation and a heat treatment buffer prolongation, where equivalence with mid length test values have been established. The length of the buffer is to be at least equal to 1 pin diameter dimension which is removed after the heat treatment cycle is finished. The test coupon can then be removed from the pin. The buffer and test are to come from the same end of the pin as per Fig.5.14.4 below:

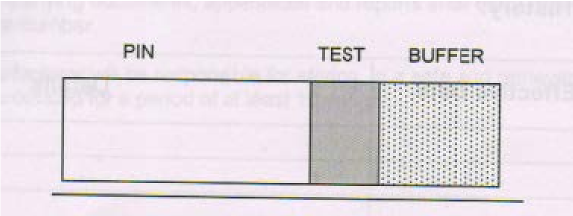


Fig.5.14.4 : Buffer and test piece location

5.14.5 Non-destructive examination

a) After proof load testing all chain accessories are to be subjected to a close visual examination. Special attention is to be paid to machined surfaces and high stress regions. All non-machined surfaces, are to be sand or shot blasted to permit a thorough examination. All accessories are to be checked by magnetic particle or dye penetrant testing.

b) Testing is to be performed in accordance with a recognized standard and the procedures, together with acceptance / rejection criteria are to be submitted to IRS for review. Operators are to be appropriately qualified, in the method of inspection, to at least level II in accordance with a recognized standard such as ISO 9712, SNT-TC-1A, EN 473 or ASNT Central Certification Program.

c) The manufacturer is to provide adequate evidence that non destructive examination has been carried out with satisfactory results together with details of technique used and to the operator's qualification.

5.14.6 Test failures

In the event of a failure of any test the entire batch represented is to be rejected unless the cause of failure is determined and it is demonstrated to the Surveyor's satisfaction that the condition causing the failure is not present in any of the remaining accessories.

5.14.7 Marking

.1 Each accessory is to be marked as follows:

- Chain grade
- Certificate No.
- IRS stamp

.2 All detachable component parts are to be stamped with a serial number to avoid mixing of components.

.3 The Certificate number may be exchanged against an abbreviation or equivalent, in which case, the details are to be stated in the certificate.

5.14.8 Documentation

.1 A complete Inspection and Testing Report in booklet form is to be provided by the manufacturer for each order. This booklet is to include all dimensional checks, test and inspection reports, NDT reports, process records as well as any nonconformity, corrective action and repair work.

.2 Each type of accessory is to be covered by separate certificates.

.3 All accompanying documents, appendices and reports are to carry reference to the original certificate number.

.4 The manufacturer will be responsible for storing, in a safe and retrievable manner, all documentation produced for a period of at least 10 years.

5.15 Chafing chain for single point mooring arrangements

5.15.1 Scope

These requirements apply to short lengths (approximately 8 m) of 76 [mm] diameter chain to be connected to hawsers for the tethering of oil tankers to single point moorings, FPSO’s and similar uses.

5.15.2 Approval of manufacturing

The chafing chain is to be manufactured by works approved by IRS according to 5.3 of this chapter.

5.15.3 Materials

The materials used for the manufacture of the chafing chain are to satisfy the requirements of 5.7 to 5.10 of this chapter.

5.15.4 Design, manufacturing, testing and certification

a) The chafing chain is to be designed, manufactured, tested and certified in accordance with 5.11 to 5.14 except that batch heat treatment is permitted.

b) The arrangement of the end connections is to be of an approved type.

c) The common link is to be of the stud link type and of Grade R3 or R4.

d) The chafing chain is to be capable of withstanding the breaking test loads of 4884 [kN] (Grade R3) and 6001 [kN] (Grade R4).

Documented evidence of satisfactory testing of similar diameter mooring chain in the prior six month period may be used in lieu of break testing subject to agreement with IRS.

e) The chain lengths shall be proof load tested in accordance with 5.13.2. The proof test loads for Grade R3 and Grade R4 are to be 3242 [kN] and 4731 [kN] respectively.

End of Chapter

Chapter 11

Approval of Welding Consumables for Use in Ship Construction

Contents

Section 1

General

1.1 Scope

1.1.1 This Chapter gives the requirements for approval and inspection of welding consumables such as electrodes, wires, fluxes etc. intended for welding of the following types of materials used in ship construction:

a) Normal strength steel for ship structures, Grades A, B, D and E (See Ch.3).

b) Higher strength steels for ship structures Grades AH32, DH32, EH32, AH36, DH36 and EH36 (See Ch.3).

c) Higher strength steels for ship structures with minimum yield strength 390 [N/mm^2] : Grades AH40, DH40 and EH40 (See Ch.3).

d) Higher strength steels for ship structures for low temperature application : Grades FH32, FH36 and FH40 (See Ch.3).

e) Higher strength quenched and tempered steels.

f) Aluminium alloys (See Ch.9).

1.2 Manufacture

1.2.1 The manufacturer's plant and method of production of welding consumables are to be such as to ensure reasonable uniformity in manufacture. IRS is to be notified of any alteration proposed to be made in the process of manufacture subsequent to approval.

1.3 Grading

1.3.1 Welding consumables for steel materials specified in 1.1.1 a) to d) above.

These consumables are divided into 3 strength groups each of which is further graded as per the Charpy V-notch impact test requirements as shown below:

Groups	**Grading**
Normal strength steel	1, 2, 3
Higher strength steel : yield strength upto 355 [N/mm^2]	1Y, 2Y, 3Y, 4Y
Higher strength steels : yield strength upto 390 [N/mm^2]	2Y40, 3Y40, 4Y40
Hydrogen marks Welding consumables of Grades 2 and 3; and of Grades 2Y, 3Y and 4Y and of Grades 2Y 40, 3Y 40 and 4Y 40, for which hydrogen content has been controlled in accordance with Sec.2.5 are identified by the mark H, HH or HHH	
The following suffixes are added after the Grade mark as applicable: S : Semi-automatic T : Two-run technique M : Multi-run technique TM : Both two-run and multi-run technique V : Vertical	

See Table 1.3.1 for correlation of welding consumables to hull structural steel grades.

1.3.2 For grading of consumables for welding higher strength quenched and tempered steels indicated in 1.1.1e) above, refer to Sec.7.

1.3.3 For grading of consumables for welding aluminium alloys indicated in 1.1.1f) above, refer to Sec.8.

Table 1.3.1 : Correlation of welding consumables to hull structural steel grades

Grades of Welding Consumables (see notes)	**Hull structural steel Grades 1)**											
	A	**B**	**D**	**E**	**AH32 /36**	**DH32 /36**	**EH32 /36**	**FH32/ 36**	**AH40**	**DH40**	**EH40**	**FH40**
1, 1S, 1T, 1M, 1TM, 1V	X											
1YS, 1YT, 1YM, 1YTM, 1YV	X				X 3)							
2, 2S, 2T, 2M, 2TM, 2V	X	X	X									
2Y, 2YS, 2YT, 2YM, 2YTM, 2YV	X	X	X	X	X							
2Y40, 2Y40S, 2Y40T, 2Y40M, 2Y40TM, 2Y40V	2)	2)	2)		X	X			X	X		
3, 3S, 3T, 3M, 3TM, 3V	X	X	X	X								
3Y, 3YS, 3YT, 3YM, 3YTM, 3YV	X	X	X	X	X	X	X					
3Y40, 3Y40S, 3Y40T, 3Y40M, 3Y40TM, 3Y40V	2)	2)	2)	2)	X	X	X		X	X	X	
4Y, 4YS, 4YT, 4YM, 4YTM, 4YV	X	X	X	X	X	X	X	X				
4Y40, 4Y40S, 4Y40T, 4Y40M, 4Y40TM, 4Y40V	2)	2)	2)	2)	X	X	X	X	X	X	X	X

1) Requirements for other grades of steels given in ch.3 but not included here will be specially considered.
2) See Note d)
3) See Note e)

a) When joining normal to higher strength structural steel, consumables of the lowest acceptable grade for either material being joined may be used.
b) When joining steels of same strength level but of different toughness grade, consumables of the lowest acceptable grade for either material being joined may be used.
c) It is recommended that controlled low hydrogen type consumables are to be used when joining higher strength structural steels to the same or lower strength level, except that other consumables may be used when the carbon equivalent is below or equal to 0.41%. When other than controlled low hydrogen type electrodes are used appropriate procedure test for hydrogen cracking may be conducted subject to approval of IRS.
d) The welding consumables approved for steel Grades AH40, DH40, EH40 and/or FH40 may also be used for welding of the corresponding grades of normal strength steels subject to the approval of IRS.
e) When joining higher strength steels using Grade 1Y welding consumables, the material thicknesses is not to exceed 25 [mm].

1.4 Approval procedure

1.4.1 Approval of welding consumables will be considered on the basis of the manufacturer's description of the works and detailed description of the method of production control, satisfactory inspection of the works by the Surveyors and compliance with the test requirements detailed in subsequent paragraphs of this Chapter.

1.4.2 When a welding consumable is manufactured in several locations of the same company, the complete series of approval tests would be carried out in one Works only. In other locations, a reduced test programme based upon the requirements of annual testing may be accepted subject to the manufacturer certifying that the materials and the fabrication process used are identical with those of the main unit.

This requirement is also applicable to all manufacturers of welding consumables under license.

Note : In case of wire flux combination for submerged arc welding where a unique powder flux is combined with different wires coming from several factories belonging to the same firm only one test series may be carried out provided the wires conform to the same technical specification.

1.4.3 The test assemblies are to be prepared under the supervision of the Surveyor, and all tests are to be carried out in his presence.

1.4.4 IRS may require, in any particular case, such additional tests or spacing requirements as may be necessary.

1.5 Test assemblies

1.5.1 The test assemblies are to be prepared and tested under the supervision of the Surveyor(s).

1.5.2 When a welded joint is performed, the edges of the plates are to be bevelled either by mechanical machining or by oxygen cutting; in the latter case, a descaling of the edges is necessary.

1.5.3 The welding conditions used such as amperage, voltage, travel speed, etc. are to be within the range recommended by the manufacturer for normal and good welding practice. Where a welding consumable is suitable for both alternating current (AC) and direct current (DC), AC is to be used for the preparation of test assemblies.

1.6 Annual inspection and tests

1.6.1 All establishments, where approved welding consumables are manufactured, and the associated quality control procedures, are to be subjected to annual inspection. On these occasions, samples of the approved consumables are to be selected by the Surveyor and subjected to the tests detailed in the subsequent paragraphs of this Chapter.

1.7 Upgrading and uprating

1.7.1 Upgrading and uprating of welding consumables will be considered only at the manufacturer's request, preferably at the time of annual testing. Generally, for this purpose, tests from butt weld assemblies will be required in addition to the normal annual approval tests.

1.7.2 Upgrading refers to notch toughness of the welding consumable while uprating refers to extension to cover higher strength level steels.

1.7.3 Any alteration to the approved consumable which may result in a change in the chemical composition and the mechanical properties of the deposited metal, must be immediately notified by the manufacturer. Additional tests may be necessary.

1.8 Dimensions of test specimens

1.8.1 Deposited metal tensile test specimens are to be machined to the dimensions shown in Fig.1.8.1. Care is to be taken to ensure that the longitudinal axis of the test piece coincides with the centre of the weld and midthickness of the plates. The test piece may be heated to a temperature not exceeding 250°C for a period not exceeding 16 hours for hydrogen removal, prior to testing.

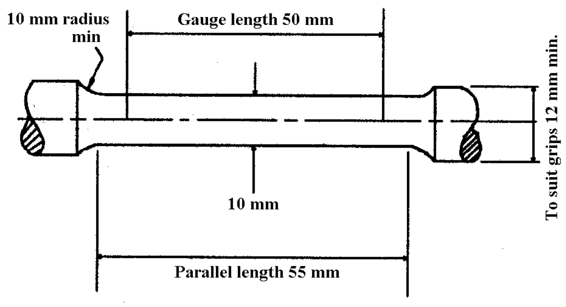


Fig.1.8.1 : Deposited metal tensile test

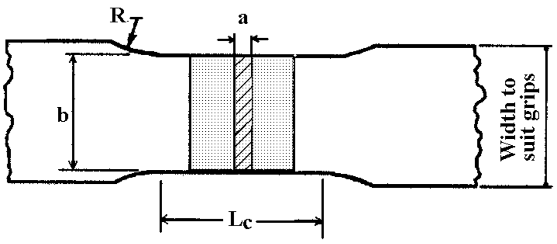


Fig.1.8.2 : Butt weld tensile test specimen

1.8.2 Butt weld tensile test specimens are to be machined to the following dimensions (see Fig.1.8.2).

a = thickness of plate 't'
b = 12 for t ≤ 2 [mm]
= 25 for t > 2 [mm]
L_c = width of weld + 60 [mm]
R > 25 [mm].

The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plates.

1.8.3 Butt weld bend test specimens are to be 30 [mm] in width. Upper and lower surfaces of the weld are to be filed, ground or machined flush with the surfaces of the plates and sharp corners of the specimens are to be rounded to a radius not exceeding 2 [mm].

1.8.4 All impact test specimens are to be of the standard 10 [mm] x 10 [mm] Charpy V-notch type, machined to the dimensions and tolerances detailed in Ch.2.

1.9 Testing procedures

1.9.1 The procedures used for all tensile and impact tests are to comply with the requirements of Ch.2.

1.9.2 Butt weld bend test specimens are to be tested at ambient temperature. The test specimens are to be capable of withstanding, without fracture, being bent through an angle of 120 degrees over a former having a diameter three times the thickness of the specimen. One specimen from each welded assembly is to be tested with the face of the weld in tension and the other with the root of the weld in tension.
The test pieces can be considered as complying with the requirements if, on completion of the test, no crack or defect at the outer surface of the test specimen can be seen.

1.9.3 Tensile Tests : On deposited metal test specimens, the values of tensile strength, yield stress and elongation are to be recorded. On butt weld specimens, the values of tensile strength and the position of fracture are to be recorded.

1.9.4 Charpy V-notch Impact Tests : A set of three test specimens is to prepared and tested. The average absorbed energy value is to comply with the requirements of subsequent sections. One individual value may be less than the required average value provided that it is not less than 70 per cent of this value.

The test temperature for Grades 2, 2Y and 3, 3Y test pieces is to be controlled within 2°C of the prescribed temperature.

1.10 Re-test procedures

1.10.1 Where the results of a tensile or bend test do not comply with the requirements, duplicate test specimens of the same type are to be prepared and are to be satisfactorily tested. Where insufficient original welded assembly is available, a new assembly is to be prepared using welding consumables from the same batch. If the new assembly is made with the same procedure (particularly the number of runs) as the original assembly, only the duplicate re-test specimens need to be tested. Otherwise, all test specimens are to be prepared and re-tested.

1.10.2 Where the results from a set of three impact test specimens do not comply with the requirements, an additional set of three impact test specimens may be taken provided that not more than two individual values are less than the required average value and, of these, not more than one is less than 70 per cent of the average value. The results obtained are to be combined with the original results to form a new average which, for acceptance, is to be not less than the required value. Additionally, for these combined results not more than two individual values are to be less than the required average value, and of these, not more than one is to be less than 70 per cent of the average value. Further retests may be made at the Surveyor's discretion, but these must be made on a new welded assembly and must include all tests required for the original assembly, even those which were previously satisfactory.

1.11 Chemical composition

1.11.1 The chemical analysis of the weld metal made by the electrode is to be supplied by the manufacturer.

Section 2

Electrodes for Normal Penetration Manual Welding

2.1 General

2.1.1 Based on the results of the Charpy V-notch impact tests, electrodes are divided into the following grades:-

For normal strength steel - Grades 1, 2 and 3

For higher tensile steel with minimum yield strength upto 355 [N/mm^2] - Grades 2Y, 3Y and 4Y. (Grade 1Y not applicable for manual welding).

For higher strength steels with minimum yield strength upto 390 [N/mm^2] - Grades 2Y40, 3Y40 and 4Y40.

2.1.2 If the electrodes are in compliance with the requirements of the hydrogen test given in 2.5, a suffix H, HH or HHH will be added to the grade mark.

2.1.3 For initial approval the tests specified in this Section including hydrogen test, if applicable, are to be carried out.

2.2 Deposited metal tests

2.2.1 Two deposited metal test assemblies are to be prepared in the downhand position as shown in Fig.2.2.1, one using 4 [mm] electrodes and the other using the largest size manufactured. If an electrode is manufactured in one diameter only, one test assembly is sufficient. Any grade of ship structural steel may be used for the preparation of these test assemblies.

2.2.2 The weld metal is to be deposited in single or multi-run layers according to normal practice and the direction of each layer is to alternate from each end of the plate, each run of the weld metal being not less than 2 [mm] and not more than 4 [mm] thick. Between each run the assembly is to be left in still air until it has cooled to 250°C but not less than 100°C, the temperature being taken in the centre of the weld, on the surface of the seam. After being welded the test assemblies are not to be subjected to any heat treatment.

2.2.3 One tensile and three impact test specimens are to be taken from each test assembly as shown in Fig.2.2.1. The impact test specimens are to be cut perpendicular to the weld, with their axes 10 [mm] from the upper surface of the plate. The notch is to be positioned in the centre of the weld and cut in the face of the test specimen perpendicular to the surface of the plate.

2.2.4 The chemical analysis of the deposited weld metal in each test assembly is to be supplied by the manufacturer and is to include the content of all significant alloying elements.

2.2.5 The results of all tests are to comply with the requirements of Table 2.2.1 as appropriate.

Table 2.2.1 : Requirements for deposited metal tests (covered electrodes)					
Grade	**Yield stress [N/mm^2] min.**	**Tensile strength [N/mm^2]**	**Minimum elongation on 50 mm gauge length [%]**	**Impact Tests**	
				Test temp. °C	**Average energy J min.**
1 2 3	305	400 - 560	22	20 0 -20	47
2Y 3Y 4Y	375	490 - 660	22	0 -20 -40	47
2Y40 3Y40 4Y40	400	510 - 690	22	0 -20 -40	47

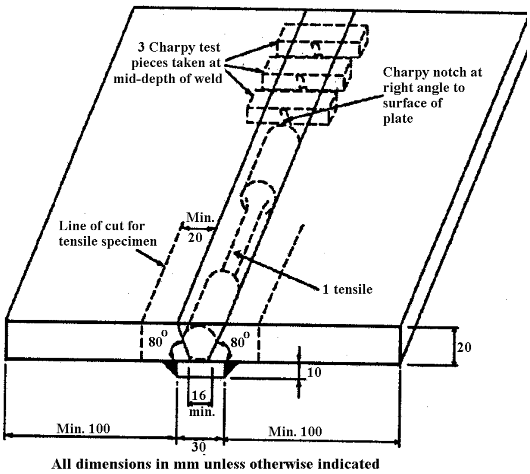


Fig.2.2.1 : Deposited metal test assembly

2.3 Butt weld tests

2.3.1 Butt weld assemblies as shown in Fig.2.3.1 are to be prepared for each welding position (downhand, horizontal-vertical, vertical-upward, vertical-downward and overhead) for which the electrode is recommended by the manufacturer, except that electrodes satisfying the requirements for downhand and vertical-upward positions will be considered as also complying with the requirements for the horizontal-vertical position.

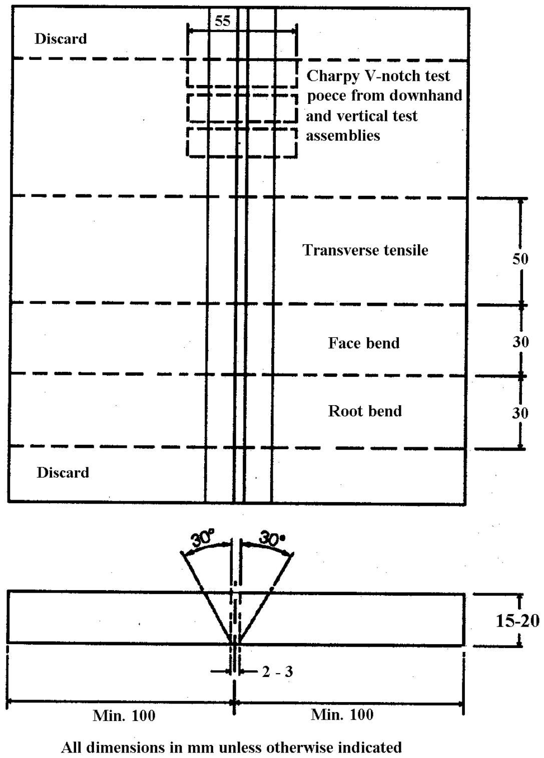


Fig.2.3.1 : Butt weld test assembly

Table 2.3.1 : Requirements for butt weld test (covered electrodes)

Grade	Tensile strength [N/mm^2] min. (transverse test)	Charpy V-notch impact test		
		Test temp. °C	Average energy J min.	
			Down-hand horizon-tal vertical, over-head	Vertical (upward and down-ward)
1 2 3	400	20 0 -20	47	34
2Y 3Y 4Y	490	0 -20 -40	47	34
2Y40 3Y40 4Y40	510	0 -20 -40	47	39

2.3.2 Where the electrode is only to be approved in the downhand position an additional test assembly is to be prepared in that position.

2.3.3 The grades of steels used for the preparation of the test assemblies are to be as follows:

Grade 1 electrodes	A
Grade 2 electrodes	A, B, D
Grade 3 electrode	A, B, D, E
Grade 2Y electrode	AH32, AH36, D32, D36
Grade 3Y electrode	AH32, AH36, DH32, DH36, EH32, EH36
Grade 4Y electrodes	AH32, AH36, DH32, DH36, EH32, EH36, FH32, FH36
Grade 2Y40 electrodes	AH40, DH40
Grade 3Y40 electrodes	AH40, DH40, EH40
Grade 4Y40 electrodes	AH40, DH40, EH40, FH40

2.3.4 Where higher strength steel with minimum yield strength 315 [N/mm^2] is used for grade 2Y, 3Y and 4Y electrodes, the actual tensile strength of the steel is to be not less than 490 [N/mm^2]. The chemical composition including the content of grain refining elements is to be reported.

2.3.5 The following welding procedure should be adopted in making the test assemblies:-

DOWNHAND (a)

First run with 4 [mm] diameter electrode. Remaining runs (except last two layers) with 5 [mm] diameter electrodes or above according to the normal welding practice with the electrodes. The runs of the last two layers with the largest size of electrode manufactured.

DOWNHAND (b)

Where a second downhand test is required:-

First run with 4 [mm] diameter electrode. Next run with an intermediate size electrode 5 [mm] or 6 [mm] diameter and the remaining runs with the largest size of electrode manufactured.

HORIZONTAL-VERTICAL

First run with 4 [mm] or 5 [mm] diameter electrode, subsequent runs with 5 [mm] diameter electrodes.

VERTICAL UPWARDS AND OVERHEAD

First run with 3.25 [mm] diameter electrode. Remaining runs with 4 [mm] diameter electrodes or possibly 5 [mm] diameter electrodes if this is recommended by the manufacturer for the positions concerned.

VERTICAL DOWNWARD

The method to be adopted is to be as recommended by the manufacturer.

2.3.6 In all cases the back sealing runs are to be made with 4 [mm] diameter electrodes in the welding position appropriate to each test sample after cutting out the root run to clean metal. For electrodes suitable for downhand welding only, the test assemblies may be turned over to carry out the back sealing run.

2.3.7 The butts are to be welded using normal welding practice and between each run the assembly is to be left in still air until it has cooled to 250°C but not below 100°C, the temperature being taken in the centre of the weld, on the surface of the seam.

2.3.8 After being welded, the test assemblies are not to be subjected to any heat treatment.

2.3.9 It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain any defects in the weld prior to testing.

2.3.10 From each test assembly one tensile, one face and one root bend and a set of three Charpy V-notch test specimens are to be prepared, except that the impact test specimens need not be prepared for test assemblies welded in the overhead position.

2.3.11 The results of all mechanical testing are to comply with the requirements of Table 2.3.1. The position of the fracture in the transverse tensile test is to be reported. The bend test specimens can be considered as complying with the requirements if, after bending, no crack or defect having dimensions exceeding 3 [mm] can be seen on the outer surface of the test specimen.

2.4 Fillet weld tests

2.4.1 When an electrode is submitted for approval for fillet welding only and to which butt weld tests, as per 2.3, are not considered applicable, the initial approval tests are to consist of the fillet weld test, described herein, and the deposited metal test as per 2.2. When the electrode is submitted for approval for both butt and fillet welding, the initial approval is to include one fillet weld test as detailed hereunder and welded in the horizontal-vertical position in addition to the tests required by 2.2 and 2.3.

2.4.2 Fillet weld assemblies as shown in Fig.2.4.1 are to be prepared for each welding position (horizontal-vertical, vertical-upwards, vertical- downwards or overhead) for which the electrode is recommended by the manufacturer. The grade of steel used is to be in accordance with 2.3.3 as appropriate. The test assemblies are to be welded using an electrode of a diameter recommended by the manufacturer. The length of the test assembly, L, is to be sufficient to allow at least the deposition of the entire length of the electrode being tested.

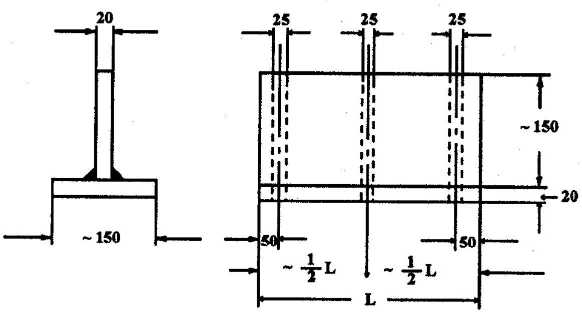


Fig.2.4.1 : Fillet weld test assembly

The first side is to be welded using the maximum size of electrode manufactured and the second side is to be welded using the minimum size of electrode manufactured and recommended for fillet welding. The fillet size will in general be determined by the electrode size and the welding current employed during testing.

2.4.3 The assembly is to be sectioned to form three macro sections each about 25 [mm] thick and the hardness readings are to be made in each section as indicated in Fig.2.4.2. The hardness of the weld is to be determined and is to meet the following listed equivalent values:-

a) Diamond Pyramid Hardness (98 N load) = 150 minimum

b) Rockwell (980 N load) B = 80 minimum

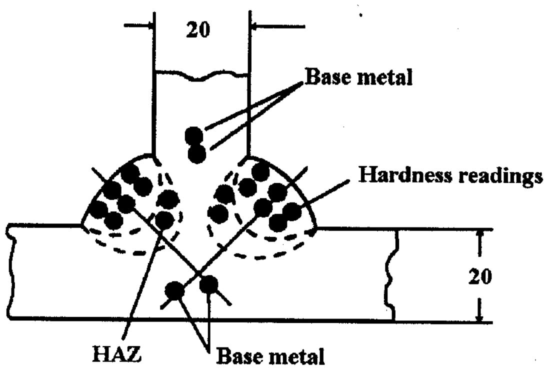


Fig.2.4.2 : Hardness tests for fillet weld test

2.4.4 The hardness of both heat affected zone and base metal is also to be determined and is to be reported for information.

2.4.5 One of the remaining sections of the assembly is to have the weld on the first side gouged or machined to facilitate breaking the fillet weld on the second side by closing the two plates together, subjecting the root of the weld to tension. On the other remaining section the weld on the second side is to be gouged or machined and the section fractured using the same procedure. The fractured surfaces are to be examined and there should be no evidence of incomplete penetrations, nor internal cracking and they should be reasonably free from porosity.

2.5 Hydrogen test

2.5.1 At the request of the manufacturer, electrodes may be submitted to a hydrogen test. A suffix H, HH or HHH will be added to the grade number to indicate compliance with the requirements of this test.

2.5.2 The mercury method as specified in the Standard ISO 3690-2000, or any method which correlates to that method may be used. Alternatively, the glycerine method as described below is to be used.

2.5.3 Glycerine method

a) Four test specimens are to be prepared measuring 12 x 25 [mm] in cross- section by about 125 [mm] in length. The parent metal may be any grade of ship building steel and, before welding, the specimens are to be weighed to the nearest 0.1 gram. On the 25 [mm] surface of each test specimen a single bead of welding is to be deposited about 100 [mm] in length by a 4 [mm] electrode using about 150 [mm] of the electrode. The welding is to be carried out with as short an arc as possible and with a current of about 150 amperes. The electrode prior to welding, can be submitted to the normal drying process recommended by the manufacturer.

b) Within thirty seconds of the completion of welding of each specimen the slag is to be removed and the specimen quenched in water at approximately 20°C. After a further thirty seconds the specimens are to be cleaned and placed in an apparatus suitable for the collection of hydrogen by displacement of glycerine. The glycerine is to be kept at a temperature of 45°C during the test. All the four specimens are to be welded and placed in the hydrogen collecting apparatus within 30 minutes.

c) The specimens are to be kept immersed in the glycerine for a period of 48 hours and, after removal, are to be cleaned in water and spirit, dried and weighed to the nearest 0.1 gram to determine the amount of weld deposited. The amount of gas evolved is to be measured to the nearest 0.05 [cm^3] and corrected for temperature and pressure to 20C and 760 [mm] Hg.

2.5.4 The individual and average diffusible hydrogen contents of the four specimens are to be reported, and the average value in [cm^3] per 100 grams is not to exceed the following:

Mark	Mercury method (ISO 3690-1977)	Glycerine Method
H	15	10
HH	8	5
HHH	5	
Note : For HHH mark, only mercury method is to be used		

2.6 Covered electrodes for gravity or contact welding

2.6.1 Where an electrode is submitted solely for approval for use in contact welding using automatic gravity or similar welding devices, deposited metal tests (see 2.2), fillet weld tests (see 2.4) and, where appropriate, butt weld tests (see 2.3) similar to those for normal manual electrodes are to be carried out using the process for which the electrode is recommended by the manufacturer.

2.6.2 Where an electrode is submitted for approval for use in contact welding using automatic gravity or similar welding devices in addition to normal manual welding, fillet weld tests (see 2.4) and, where appropriate, butt weld tests (see 2.3) similar to those for normal manual electrodes are to be carried out using the process for which the electrode is recommended by the manufacturer and these tests are to be in addition to the normal approval tests.

2.6.3 In the case of approval of a fillet welding electrode using automatic gravity or similar contact welding devices, the fillet welding is to be carried out using the welding process recommended by the manufacturer, with the longest size of electrode manufactured. The manufacturer's recommended current range is to be reported for each electrode.

2.6.4 Where approval is requested for the welding of both normal strength and higher tensile steels, the assemblies are to be prepared using higher tensile steel.

2.7 Annual tests

2.7.1 For normal penetration electrodes, the annual tests are to consist of two deposited metal test assemblies. These are to be prepared and tested in accordance with 2.2. If an electrode is available in one diameter only, one test assembly is sufficient.

2.7.2 Where an electrode is approved solely for gravity or contact welding, the annual test is to consist of one deposited metal test assembly using the gravity or other contact device as recommended by the manufacturer.

2.8 Upgrading and uprating

2.8.1 Upgrading and uprating will be considered only at the manufacturer's request and preferably at the time of annual testing. Tests on butt weld assemblies, in addition to the requirements of annual testing, are to be carried out.

2.9 Certification

2.9.1 Each carton or package of approved electrode is to contain a certificate from the manufacturer generally in accordance with the following:-

"The .... company certifies that composition and quality of these electrodes conform with those of the electrodes used in making the test pieces submitted to and approved by Indian Register of Shipping."

Section 3

Deep Penetration Electrodes for Manual Welding

3.1 General

3.1.1 Where an electrode is designed solely for the deep penetration welding of downhand butt joints and horizontal-vertical fillets, only the test detailed in 3.2 and 3.3 are required for initial approval purposes.

3.1.2 Deep penetration electrodes will only be approved as complying with Grade 1 requirements. The suffix D.P. will be added.

3.1.3 Where a manufacturer recommends that an electrode having deep penetrating properties can also be used for downhand butt welding of thicker plates with prepared edges, the electrode will be treated as normal penetration electrode, and the full series of tests in the downhand position is to be carried out as per normal penetration electrode, together with deep penetration tests given in 3.2 and 3.3.

3.1.4 Where a manufacturer desires to demonstrate that an electrode in addition to its use as normal penetration electrode also has deep penetrating properties when used for downhand butt welding and horizontal - vertical fillet welding, the additional tests given in 3.2 and 3.3 are to be carried out.

3.1.5 Where the manufacturer prescribes a different welding current and procedure for the electrode when used as a deep penetration electrode and a normal penetration electrode, the recommended current and procedure are to be used when making the test specimens in each case.

3.2 Deep penetration butt weld tests

3.2.1 Two plates of thickness equal to twice the diameter of the core of the electrode plus 2 [mm] are to be butt welded together with one downhand run of welding from each side. The plates are to be not less than 100 [mm] wide and of sufficient length to allow the cutting out of the test specimens of the correct number and size as shown in Fig.3.2.1. Grade A steel is to be used for these test assemblies. The joint edges are to be prepared square and smooth and, after tacking, the gap is not to exceed 0.25 [mm].

3.2.2 The test assembly is to be welded using a 8 [mm] diameter electrode or the largest diameter size manufactured if this is less than 8 [mm].

3.2.3 After welding the test assembly is to be cut to form two transverse tensile test pieces, two bend test pieces and three Charpy V-notch test pieces as shown in Fig.3.2.1. The results of tensile and impact testing are to comply with the requirements of Table 2.3.1 for Grade 1 electrodes.

3.2.4 The discards at the end of the welded assemblies are to be not more than 35 [mm] wide. The joints of these discards are to be polished and etched and must show complete fusion and interpenetration of the welds. At each cut in the test assembly the joints are also to be examined to ensure that complete fusion has taken place.

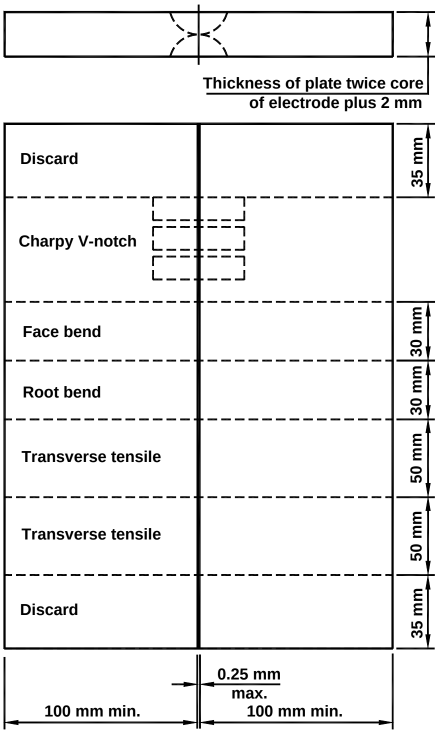


Fig. 3.2.1 : Deep penetration butt weld test assembly

3.3 Deep penetration fillet weld test

3.3.1 A fillet weld assembly is to be prepared as shown in Fig.3.3.1 with plates about 12.5 [mm] in thickness. The welding is to be carried out with one run for each fillet with plate A in the horizontal plane during the welding operations. The length of the fillet is to be 160 [mm] and the gap between the plates is to be not more than 0.25 [mm]. Grade A steel is to be used for these test assemblies.

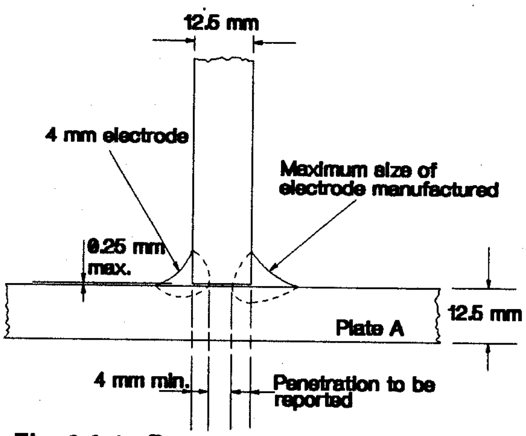


Fig. 3.3.1 : Deep penetration fillet weld test assembly

3.3.2 The fillet weld on one side of the assembly is to be carried out with 4 [mm] electrode and that on the other side with the maximum size of the electrode manufactured. The welding current used is to be within the range recommended by the manufacturer and the welding is to be carried out using normal welding practice.

3.3.3 The welded assembly is to be cut by sawing or machining within 35 [mm] of the ends of the fillet welds and the joints are to be polished and etched. The welding of the fillet made with a 4 [mm] electrode is to show a penetration of 4 [mm] (See Fig.3.3.1) and the corresponding penetration of the fillet made with the maximum size of electrode manufactured is to be reported.

3.4 Electrodes designed for gravity or contact welding

3.4.1 This type of approval is available for welding only normal strength and higher tensile steels with minimum specified yield strengths up to 345 [N/mm^2].

3.4.2 Where an electrode is submitted solely for approval for use in contact welding using automatic gravity or similar welding devices, deposited metal tests, and where appropriate, fillet weld tests similar to those for normal manual electrodes are to be carried out using the process for which the electrode is recommended by the manufacturer.

3.4.3 Where an electrode is submitted for approval for use in contact welding using automatic gravity or similar welding devices in addition to normal manual welding, butt weld and, where appropriate, fillet weld tests, using gravity or other contact device as recommended by the manufacturer, are to be carried out in addition to the normal approval tests.

3.5 Annual tests

3.5.1 Where an electrode is approved only for deep penetration welding, the annual test is to consist of one butt welded test assembly in accordance with 3.2.

3.5.2 Where an electrode is approved for both normal and deep penetration welding, annual tests are to consist of following:-

a) Two deposited metal test assemblies in accordance with 2.2; and

b) One butt welded test assembly in accordance with 3.2.

3.5.3 Where an electrode is approved solely for gravity or contact welding, the annual test is to consist of one deposited metal test assembly using the gravity or other contact device as recommended by the manufacturer.

3.6 Certification

3.6.1 Each carton or package of approved electrodes is to contain a certificate from the manufacturer generally in accordance with 2.9.

Section 4

Wire-flux Combinations for Submerged Arc Automatic Welding

4.1 General

4.1.1 Wire-flux combinations for single electrode submerged-arc automatic or semi-automatic welding are divided into following two categories:-

a) For use with multi-run technique;

b) For use with two-run technique.

Where wire-flux combinations are suitable for welding with both the techniques, tests are to be carried out for each technique.

Wire-flux combinations for multiple electrode submerged arc welding will be subject to separate approval tests. They are to be carried out generally in accordance with the requirements of this section.

4.1.2 Dependent on the results of impact tests, wire-flux combinations are divided into the following grades:-

For normal strength steel - Grades 1, 2 or 3;

For higher strength steel with minimum yield strength upto 355 [N/mm^2] - Grades 1Y, 2Y, 3Y or 4Y.

For higher strength steels with minimum yield strength upto 390 [N/mm^2] - Grades 2Y40, 3Y40 or 4Y40.

4.1.3 The suffixes T, M or TM will be added to the grade mark to indicate two-run technique, multi-run technique or both techniques respectively.

4.1.4 The welding current may be either a.c. or d.c. (electrode positive or negative) according to the recommendation of the manufacturer. If both a.c. and d.c. are recommended, a.c. is to be used for the tests.

4.2 Multi-run technique

4.2.1 When approval for use with multi-run technique is required, deposited metal and butt weld tests are to be carried out in accordance with 4.3 and 4.4 respectively.

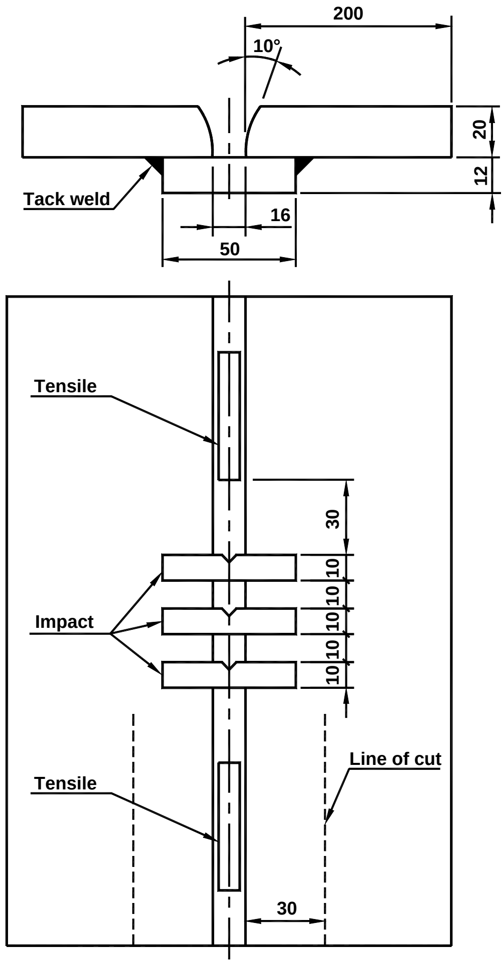
4.3 Deposited metal tests

4.3.1 An all weld metal test assembly is to be prepared in the downhand position as shown in Fig.4.3.1, using any grade of hull structural steel.

4.3.2 The bevelling of the plate edges is to be carried out by machining or mechanized gas cutting. In the latter case any remaining scale is to be removed from the bevelled edges.

4.3.3 The direction of deposition of each run is to alternate from each end of the plate and after completion of each run the flux and welding slag is to be removed. Between each run the assembly is to be left in still air until it has cooled to 250°C but not below 100°C, the temperature being taken in the centre of the weld, on the surface of the seam. The thickness of the layer is to be not less than the diameter of the wire but not less than 4 [mm].

4.3.4 The welding conditions (amperage, voltage and rate of travel) are to be in accordance with the recommendations of the manufacturer and are to conform with normal good welding practice for multi-run welding.



All dimensions in mm unless otherwise indicated

Fig. 4.3.1 : Deposited metal test assembly

4.3.5 The welded assembly is to be cut longitudinally at a distance of 30 [mm] from the edges of the weld and then cut transversely.

4.3.6 Two longitudinal tensile and three impact test specimens are to be taken from each test assembly as shown in Fig.4.3.1. Care is to be taken that the axes of the tensile test specimens coincide with the centre of the weld and the midthickness of the plates. The impact test specimens are to be cut perpendicular to the weld with their axes 10 [mm] from the upper surface. The notch is to be positioned in the centre of the weld and cut in the face of the test specimen perpendicular to the surface of the plate.

4.3.7 The results of all tests are to comply with requirements of Table 4.3.1 as appropriate. The chemical analysis of the deposited weld metal including the content of the significant alloying elements is to be submitted by the manufacturer.

Table 4.3.1 : Requirements for deposited metal tests (wire-flux combinations)

Grade	Yield stress [N/mm^2]	Tensile strength [N/mm^2]	Elongation on 50 mm gauge length % min.	Charpy V-notch impact	
				Test temp. °C	Avg. energy - J min.
1 2 3	305	400 - 560	22	20 0 -20	34
1Y 2Y 3Y 4Y	375	490 - 660	22	20 0 -20 -40	34
2Y40 3Y40 4Y40	400	510 - 690	22	0 -20 -40	39

4.4 Butt weld test (two-run technique)

4.4.1 Two welded assemblies for each grade of wire-flux combination are to be prepared in accordance with Fig.4.4.1, using the following plate thicknesses:-

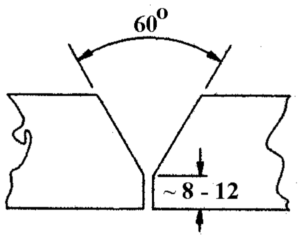
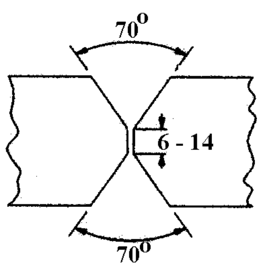
For Grades 1 and 1Y	12 to 15 [mm] and 20 to 25 [mm]
For Grades 2, 2Y, 3, 3Y and 4Y	20 to 25 [mm] and 30 to 35 [mm]
For Grades 2Y40, 3Y40 and 4Y40	20 to 25 [mm] and 30 to 35 [mm]

A limitation of the approval to the medium range (upto the maximum welded plate thickness) may be agreed in which case the test assemblies are to be welded using plates of 12 to 15 [mm] and 20 to 25 [mm] irrespective of the grade for which the approval is requested.

Where approval is requested for welding of both normal strength and higher tensile steel, two assemblies are to be prepared using higher tensile steel.

4.4.2 The maximum diameter of wire, grades of steel plate and edge preparation to be used are to be in accordance with Table 4.4.2. Small deviations in the edge preparation may be allowed if requested by the manufacturer. The bevelling of the plate edges is to be performed by machining or mechanized gas cutting. In the latter case any remaining scale is to be removed from the bevelled edges. The root gap should not exceed 1.0 [mm].

Table 4.4.2 : Butt weld test assemblies (two-run technique)

Plate thick-ness [mm]	Recommended preparation [mm]	Max. diameter of wire [mm]	Grade of wire-flux combi-nation	Grade of normal strength steel	Grade of higher strength steel
About 12 -15		5	1	A	-
			1Y	-	AH32 AH36
About 20 - 25		6	1	A	-
			1Y	-	AH32, AH36
			2	A,B or D	-
			2Y	-	AH32, AH36, DH32, DH36
			2Y40	-	AH40, DH40
			3	A,B,D or E	-
			3Y	-	AH32, AH36, DH32 DH36, EH32, EH36
			3Y40	-	AH40, DH40, EH40
			4Y	-	AH32, AH36, DH32, DH36 EH32, EH36, FH32, FH36
			4Y40	-	AH40, DH40, EH40, FH40
About 30 - 35		7	2	A, B or D	-
			2Y	-	AH32, AH36, DH32, DH36
			2Y40	-	AH40, DH40
			3	A, B, D or E	-
			3Y	-	H32, AH36, DH32, DH36, EH32, EH36
			3Y40	-	AH40, DH40, EH40
			4Y	-	AH32, AH36, DH32, DH36, EH32, EH36, FH32, FH36
			4Y40	-	AH40, DH40, EH40, FH40

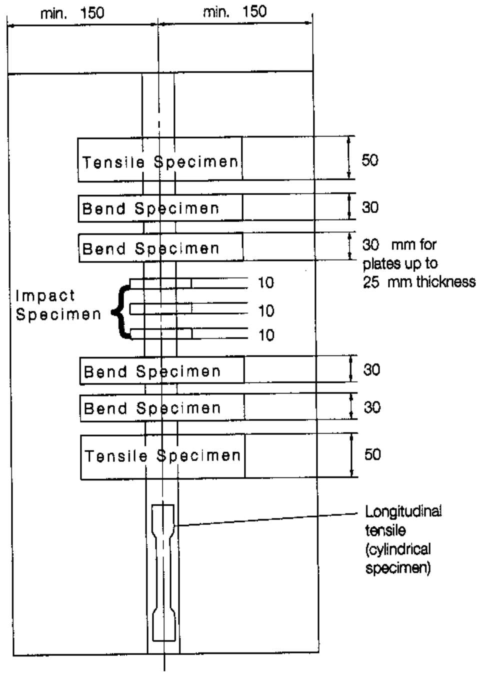


Fig.4.4.1 : Butt weld test assembly (two-run technique)

4.4.3 The welding current may be either a.c. or d.c. (electrode positive or negative) according to the recommendation of the manufacturer. If both a.c. and d.c. are recommended a.c. is to be used for test pieces.

4.4.4 Each butt weld is to be welded in two runs, one from each side, using amperages, voltages and travel speeds in accordance with the recommendations of the manufacturer and normal good welding practice.

4.4.5 After completion of the first run, the flux and welding slag are to be removed and the assembly is to be left in still air until it has cooled to 100°C, the temperature being taken in the centre of the weld, on the surface of the seam. After being welded the test assemblies are not to be subjected to any heat treatment.

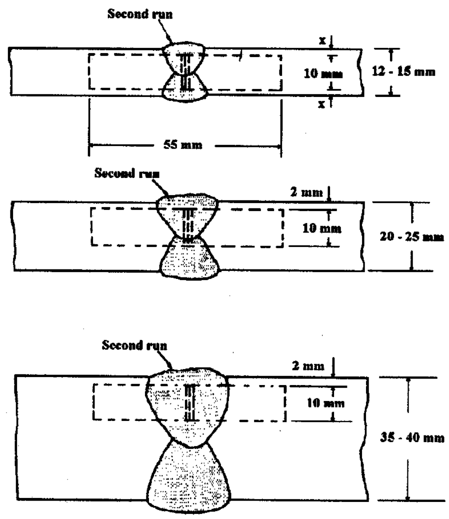


Fig. 4.4.3 : Butt weld test assemblies - two-run technique : position of impact test specimens

4.4.6 It is recommended that welded assemblies be subjected to radiographic examination to ascertain any defects in the weld prior to testing.

4.4.7 The assemblies are to be cut transversely, to form two tensile test pieces and two bend test pieces as shown in Fig.4.4.1, three impact test pieces as shown in Fig.4.4.1 and Fig.4.4.3. The edges of all test pieces and also the discards are to be examined to ensure complete fusion and interpenetration of welds.

4.4.8 Where the wire-flux combination is to be used for two-run technique only, a longitudinal test is also to be made in accordance with Fig.4.5.1 on the thicker plate tested.

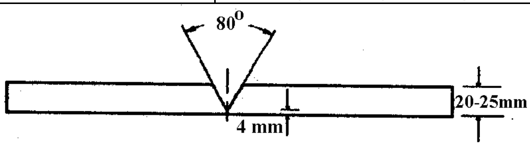
4.4.9 The results of the transverse tensile and impact tests are to comply with the requirements of Table 4.5.1 as appropriate. The results of longitudinal tensile test are to comply with the requirements of Table 4.3.1 as appropriate except that for Grades 1Y, 2Y and 3Y the tensile strength is not to be less than 490 [N/mm^2].

4.5 Butt weld test (multi-run technique)

4.5.1 A butt weld assembly, as shown in Fig.4.5.1, is to be prepared in the downhand position by welding together two 20 [mm] thick plates of not less than 150 [mm] in width and of sufficient length to allow the cutting out of test specimens of the prescribed number and size.

4.5.2 The grade of steel used for the preparation of the test assembly is to be as follows:-

Grade 1 wire-flux combination	Grade A
Grade 2 wire-flux combinations	Grade A, B, D
Grade 3 wire-flux combinations	Grade A, B, D, E
Grade 1Y wire-flux combinations	Grade AH32, AH36
Grade 2Y wire-flux combinations	AH32, AH36, DH32, DH36
Grade 3Y wire-flux combinations	AH32, AH36, DH32, DH36, EH32, EH36
Grade 4Y wire-flux combinations	AH32, AH36, DH32, DH36, EH32, EH36, FH32, FH36
Grade 2Y40 wire-flux combinations	AH40, DH40
Grade 3Y40 wire-flux combinations	AH40, DH40, EH40
Grade 4Y40 wire-flux combinations	AH40, DH40, EH40, FH40



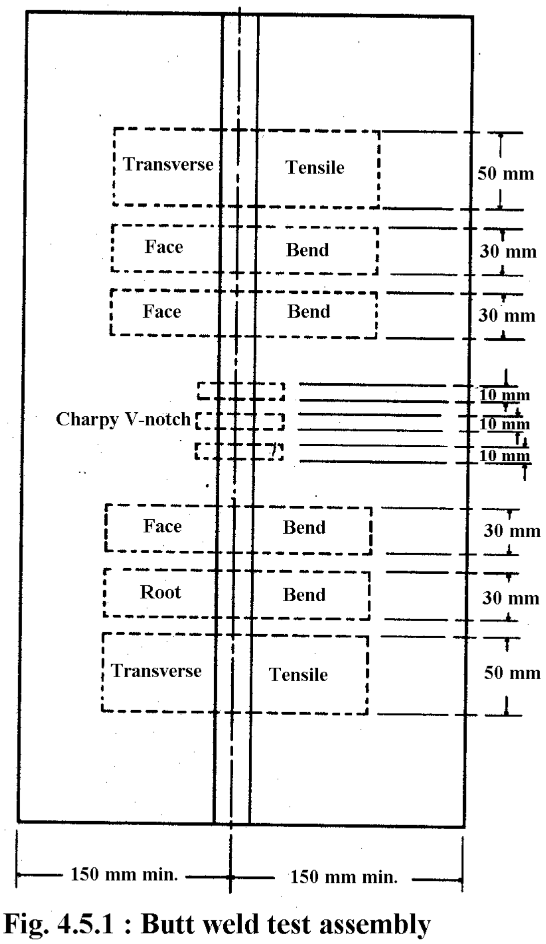


Fig. 4.5.1 : Butt weld test assembly (multi-run technique)

4.5.3 Welding is to be carried out in the downhand position, and the direction of deposition of each run is to alternate from each end of the plate. After completion of each run, the flux and welding slag is to be removed. Between each run the assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken in the centre of the weld, on the surface of the seam. The thickness of the layer is to be not less than the diameter of the wire nor less than 4 [mm].

4.5.4 The plate edges are to be prepared to form a single vee joint, the included angle between the fusion faces being 60 degrees and the root face being 4 [mm]. The bevelling of the plate edges is to be carried out by machining or mechanized gas cutting. In the latter case, any remaining scale is to be removed from the bevelled edges.

4.5.5 The welding is to be carried out by the multi-run technique and the welding conditions are to be the same as those adopted for the deposited metal test assembly.

4.5.6 The back sealing run is to be applied in the downhand position after cutting out the root run to clean metal. After being welded the test assembly is not to be subjected to any heat treatment.

4.5.7 It is recommended that the welded assembly be subjected to radiographic examination to ascertain any defects in the weld prior to testing.

4.5.8 The test assembly is to be cut to form two tensile; two face bend; two root bend; three impact test pieces as shown in Fig.4.5.1.

4.5.9 The results of all tensile and impact test specimens are to comply with the requirements of Table 4.5.1 as appropriate. The position of the fracture of the transverse tensile test is to be reported.

Table 4.5.1 : Requirements for butt weld tests (wire flux-combination)

Grade	Tensile strength (transverse test) [N/mm^2] min.	Charpy V-notch impact test	
		Test temp. °C	Avg. energy J min. (See note)
1 2 3	400	20 0 -20	34
1Y 2Y 3Y 4Y	490	20 0 -20 -40	34
2Y40 3Y40 4Y40	510	0 -20 -40	39
Note : No individual impact test value is to be less than 23J			

4.6 Annual tests

4.6.1 Following tests on wire-flux combinations are to be carried out at the time of annual inspection:-

a) For two-run technique :- On butt weld assembly with 20 [mm] minimum plate thickness : One transverse tensile, two transverse bends and three impact tests. One longitudinal tensile test specimen is also to be prepared where the wire-flux combination is approved solely for the two-run technique.

b) For multi-run technique :- Deposited metal Tests - One tensile and three impact tests in accordance with 4.3.

4.6.2 The specimens are to be prepared and tested in accordance with, and on grades of steel specified for initial approval tests and the results are to comply with the results of the approved grade.

4.7 Upgrading and uprating

4.7.1 Requests for upgrading and uprating will generally be considered at the time of annual testing and additional tests in accordance with the requirements of 2.8 would be required.

Section 5

Wires and Wire-gas Combinations for Semi-automatic and Automatic Welding

5.1 General

5.1.1 Wire-gas combinations and flux-cored or flux-coated wires (for use with or without a shielding gas) are divided into following categories for the purposes of approval testing:-

a) For use in semi-automatic multi-run welding;

b) For use in single electrode multi-run automatic welding; and

c) For use in single electrode two-run automatic welding.

5.1.2 The term 'semi-automatic' is used to describe processes in which the weld is made manually by a welder holding a gun through which the wire is continuously fed. A suffix S will be added after the grade mark to indicate approval for semi-automatic multi-run welding.

5.1.3 Dependent on the results of impact tests, wires and wire-gas combinations are divided into the following grades:-

For normal strength steel	Grades 1, 2 and 3
For higher strength steel with minimum yield strength upto 355 [N/mm^2]	Grades 1Y, 2Y, 3Y and 4Y.
For higher strength steels with minimum yield strength upto 390 [N/mm^2]	Grades 2Y40, 3Y40 and 4Y40

5.1.4 For wires intended for automatic welding, the suffixes T, M or TM will be added after the grade mark to indicate approval for two-run, multi- run or both welding techniques, respectively.

5.1.5 For wires intended for both semi-automatic and automatic welding, the suffixes will be added in combination.

5.1.6 Where applicable, the composition of the shielding gas is to be reported. Unless otherwise agreed, additional approval tests are required when the shielding gas is different from that used for the original approval tests.

Where a wire in combination with any particular gas has been approved, usage of the same wire with another gas in the same group as defined in Table 5.1.6 may be considered.

5.1.7 Flux-cored or flux-coated wires which have satisfied the requirements for Grades 2, 2Y, 2Y40, 3, 3Y, 3Y40, 4Y or 4Y40 may, at the option of the manufacturer, be submitted to the hydrogen test as detailed in 2.5 using the manufacturer's recommended welding conditions and adjusting the deposition rate to give a weight of weld deposit per sample similar to that deposited when using manual electrodes. A suffix H, HH or HHH will be added to the grade mark, in the same conditions as for manual arc welding electrodes to indicate compliance with the requirements of the test.

Table 5.1.6 : Compositional limits of designated groups of gas types and mixtures

Group		Gas Composition (Vol. %)			
		CO_2	O_2	H_2	Ar
M1	1	> 0 to 5	-	> 0 to 5	Rest 1) 2)
	2	> 0 to 5	-	-	
	3	-	> 0 to 3	-	
	4	> 0 to 5	> 0 to 3	-	
M1	1	> 5 to 25	-	-	Rest 1) 2)
	2	-	3 to 10	-	
	3	> 5 to 25	> 0 to 3	-	
M1	1	> 25 to 50	-	-	Rest 1) 2)
	2	-	> 10 to 15	-	
	3	> 5 to 50	> 8 to 15	-	
C	1	100	-	-	Rest 1) 2)
	2	Rest	> 0 to 30	-	

1) Argon may be substituted by Helium upto 95% of the Argon content.

2) Approval covers gas mixtures with equal or higher Helium contents only.

5.2 Approval tests for two-run automatic welding

5.2.1 Approval tests for two-run automatic welding are to be carried out generally in accordance with the requirements of Sec.4 using the two-run automatic welding technique for the preparation of all test assemblies.

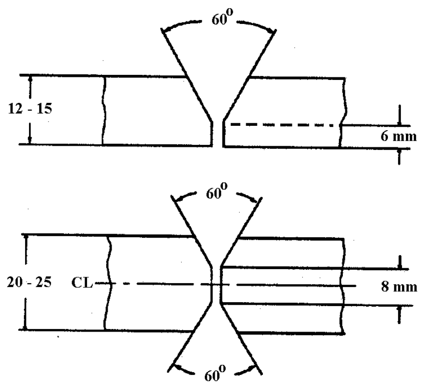


Fig.5.2.1 : Recommended edge preparation for two-run butt weld test assemblies

5.2.2 Two butt weld test assemblies are to be prepared generally as detailed in 4.4.1 and 4.4.2 using plates 12-15 [mm] and 20-25 [mm] in thickness.

5.2.3 If approval is requested for welding plates thicker than 25 [mm], one assembly is to be prepared using plates approximately 20 [mm] in thickness and the other using plates of maximum thickness for which approval is requested.

5.2.4 The edge preparation of test assemblies is to be as shown in Fig.5.2.1. Small deviations in the edge preparation may be allowed, if requested by the manufacturer. For assemblies using plates over 25 [mm] in thickness, the edge preparation is to be reported for information.

5.3 Approval tests for semi-automatic multi-run welding

5.3.1 Approval tests for semi-automatic multi-run welding are to be carried out generally in accordance with the requirements of Sec.2, using the semi-automatic multi-run technique for the preparation of all test assemblies.

5.3.2 Two deposited metal test assemblies are to be prepared in the downhand position as shown in Fig.2.2.1, one using the smallest diameter, and the other using the largest diameter of the wire intended for the welding of ship structures. The weld metal is to be deposited according to the practice recommended by the manufacturer, and the thickness of each layer of weld metal is to be between 2 [mm] and 6 [mm]. Where only one diameter is manufactured, only one deposited metal assembly is to be prepared.

5.3.3 Butt weld assemblies as shown in Fig.2.3.1 are to be prepared for each welding position (downhand, horizontal-vertical, vertical-upwards, vertical-downwards and overhead) for which the wire is recommended by the manufacturer.

5.3.4 The downhand assembly is to be welded using, for the first run, wire of 1.2 [mm] diameter or of the smallest diameter manufactured and, for the remaining runs, wire of 2.4 [mm] diameter or the largest diameter manufactured.

5.3.5 Where approval is requested only in the downhand position, an additional butt weld assembly is to be prepared in that position using wires of different diameter from those required by 5.3.4.

5.3.6 The butt weld assemblies, in positions other than downhand, are to be welded using for the first run, wire of 1.2 [mm] diameter or of the smallest diameter manufactured, and for the remaining runs, the largest diameter of wire recommended by the manufacturer for the position concerned.

5.3.7 Fillet weld test in accordance with Sec.2 is to be carried out.

5.4 Approval tests for multi-run automatic welding

5.4.1 Approval tests for multi-run automatic welding are to be carried out generally in accordance with the requirements of Sec.4 using the multi-run automatic welding technique for the preparation of all test assemblies.

5.4.2 One deposited metal test assembly is to be prepared as shown in Fig.4.3.1. Welding is to be as detailed in Sec.4 except that thickness of each layer is to be not less than 3 [mm].

5.4.3 A butt weld assembly is to be prepared, as shown in Fig.4.5.1.

5.5 Annual tests

5.5.1 The annual tests are to consist of at least the following:-

a) Wires approved for semi-automatic or for both semi-automatic and automatic multi-run welding: One deposited metal test assembly prepared in accordance with 5.3 using a wire of diameter within the range intended for the welding of the ship structures;

b) Wires approved for automatic multi-run welding: One deposited metal test assembly prepared in accordance with 5.4 using a wire of diameter within the range intended for the welding of the ship structure;

c) Wires approved for two-run automatic welding: One butt weld test assembly prepared in accordance with 5.2 using plates 20 to 25 [mm] in thickness. The diameter of the wire used is to be reported.

5.5.2 From the test assemblies prepared in accordance with 5.5.1, only the following tests are to be carried out:-

a) For deposited metal assemblies: One tensile and three impact tests;

b) For butt weld assemblies: One transverse tensile, two bend and three impact tests. One longitudinal tensile test is also required where the wire is approved solely for two-run automatic welding.

5.6 Upgrading and uprating

5.6.1 Requests for upgrading and uprating will generally be considered at the time of annual testing and additional tests in accordance with the requirements of 2.8 would be required.

Section 6

Consumables for use in Electro-slag and Electro-gas Vertical Welding

6.1 General

6.1.1 The requirements for the two-run technique as detailed in Sec.4 are applicable for the approval of special consumable used in electro-slag and electro-gas vertical welding with or without consumable nozzles except as otherwise required by the following requirements especially as regards the number and kind of the test-pieces used for the mechanical tests and taken from the butt welded assemblies.

6.1.2 For Grades 1Y, 2Y, 3Y, 4Y, 2Y40, 3Y40 and 4T40 approval of the consumables may be restricted for use only with specific types of higher tensile steel. This is in respect of the content of grain refining elements, and if general approval is required, a niobium treated steel is to be used for the approval tests.

6.1.3 For these special welding consumables, the requirements of 1.3 may not be entirely applicable for technical reasons.

Where approval is requested for welding of both normal strength and higher tensile steel two assemblies are to be prepared using higher tensile steel. Two assemblies prepared using normal strength steel may also be required at the discretion of IRS.

6.2 Butt weld tests

6.2.1 Preparation of test assemblies

- Two butt weld test assemblies are to be prepared, one of them with plates 20/25 [mm] thick, the other with plates 35/40 [mm] thick or more. The grade of the steel to be used for each one of these assemblies must be selected according to the requirements given in the Table 4.4.2.

- The chemical composition of the plate, including the content of grain refining elements is to be reported.

- The welding conditions and the edges preparation are to be those recommended by the welding consumable manufacturer and are to be reported.

6.2.2 Radiographic examination

It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain if there are any defects in the weld prior to the preparation of test specimens.

6.2.3 Test series

- Each assembly shall be cut to give test specimens according to Fig.6.2.1.

The length of the assembly should be sufficient to allow the selection of all the following test specimens :

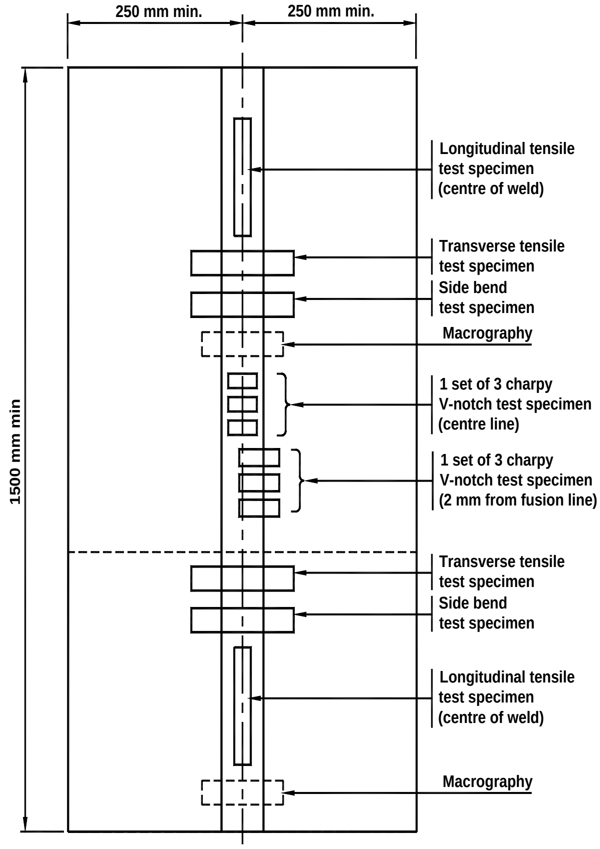


Fig. 6.2.1 : Butt weld test assembly

- 2 longitudinal tensile test specimens with their axis at the centre of the weld;

- 2 transverse tensile test specimens;

- 2 side bend test specimens;

- 2 sets of 3 Charpy-V notch impact test specimens in accordance with Fig.6.2.1 comprising of :

- 1 set with the notch in the axes of the weld;

- 1 set with the notch at 2 [mm] from the fusion line in the deposited metal; and

- 2 macro-sections of the weld (towards the middle of the weld and towards one end).

6.2.4 Results to be obtained

The results of the tensile, bend and impact tests are to comply with the requirements of 4.4 (two-run welding) for the class of filler product in question.

6.3 Annual tests

6.3.1 One test assembly must be prepared from plates 20/25 [mm] thick, and tested as indicated in 6.2.

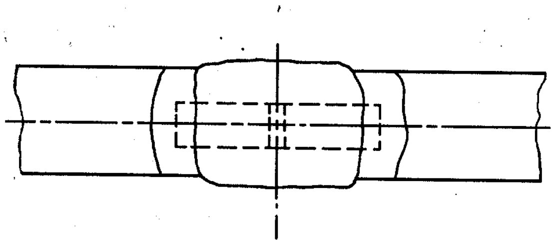
The following specimens are to be selected :

- 1 longitudinal tensile specimen from the axis of the weld:
- 1 transverse tensile specimen;
- 2 side bend specimens;
- 3 Charpy-V specimens notched at the centre of the weld (position 1 Fig.6.3.1);
- 3 Charpy-V specimens cut out transverse to the weld with their notches at 2 [mm] from the fusion line, in the weld; and
- macro section.

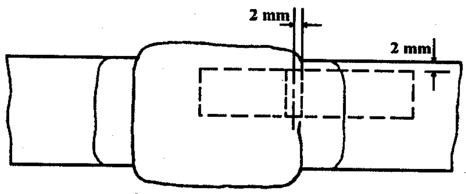
6.3.2 The results to be obtained should meet the requirements given in 4.4 (two-run welding) for the class of the consumables in question.

6.4 Upgrading and uprating

6.4.1 Upgrading and uprating will be considered only at the manufacturers request, preferably at the time of annual testing. Generally, for this purpose, full tests from butt weld assemblies as indicated in 6.2 will be required, irrespective of the other tests requested if the concerned consumable is also approved (and possibly upgraded or uprated) according to Sec.4 or Sec.5.



(1) In the centre of the weld metal



(2) In the weld metal, 2 mm from the fusion line

Fig.6.3.1 : Position of Charpy V-notch impact test specimens

Section 7

Welding Consumables for High Strength Quenched and Tempered and TMCP Steels for Welded Structures

7.1 General

7.1.1 Scope

7.1.1.1 These requirements supplement the requirements of Sections 1 to 6 and give the conditions of approval and inspection of welding consumables used for high strength quenched and tempered or TMCP steels for welded structures according to Ch.3, Sec.4 with yield strength levels from 420 [N/mm^2] upto 690 [N/mm^2] and impact grades AH, DH, EH and FH.

Where no special requirements are given, those of Sections 1 to 6 apply in analogous manner.

7.1.1.2 The welding consumables preferably to be used for the steels concerned are divided into several categories as follows:

- covered electrodes for manual welding,
- wire-flux combinations for multirun submerged arc welding,
- solid wire-gas combinations for arc welding (including rods for gas tungsten arc welding),
- flux cored wire with or without gas for arc welding.

7.1.2 Grading, Designation

7.1.2.1 Based on the yield strength of the weld metal, the welding consumables concerned are divided into six (yield) strength groups:

Y42 for welding steels with minimum yield strength 420 [N/mm^2]

Y46 for welding steels with minimum yield strength 460 [N/mm^2]

Y50 for welding steels with minimum yield strength 500 [N/mm^2]

Y55 for welding steels with minimum yield strength 550 [N/mm^2]

Y62 for welding steels with minimum yield strength 620 [N/mm^2]

Y69 for welding steels with minimum yield strength 690 [N/mm^2]

Wire-flux combinations for single or two-run technique are subject to special consideration of IRS.

7.1.2.2 Each of the six (yield) strength groups is further divided into three main grades in respect of charpy V-notch impact test requirements (test temperatures):

Grade	Test temperature
3	- 20°C
4	- 40°C
5	- 60°C

7.1.2.3 Analogously to the designation scheme used in Section 1 to 6 the welding consumables for high strength quenched and tempered steels are subject to additional designation and approval as follows:

- According to 7.1.2.2 with the quality grades 3, 4 or 5.
- With the added symbol Y and an appended code number designating the minimum yield strength of the weld metal corresponding to 7.1.2.1 : Y42, Y46, Y50, Y55, Y62 and Y69.
- With the added symbol HH or HHH for controlled hydrogen content of the weld metal.
- With the added symbol S (= semi-automatic) for semi-mechanised welding.
- With the added symbol M designating multirun technique and is applicable only to welding consumables for fully mechanised welding).

7.1.2.4 Each higher quality grade includes the one (or those) below, AH, DH steels according to Ch.3, Sec.4 are to be welded using welding consumables of at least quality grade, 3, grade EH steels using at least quality grade 4 and grade FH steels using at least quality grade 5, as per the following table:

Consumables Grade	Steel Grades covered
3Y..	DH..
4Y..	EH..and FH..
5Y..	FH.., EH.. and DH..

7.1.2.5 Welding consumables approved with grades ..Y42, ..Y46 and ..Y50 are also considered suitable for welding steels in the two strength levels below that for which they have been approved. Welding consumables approved with grades ..Y55, ..Y62 and ..Y69 are also considered suitable for welding steels in the strength level below that for which they have been approved.

7.1.2.6 IRS may, in individual cases, restrict the range of application in (up to) such a way, that approval for any one strength level does not justify approval for any other strength level.

7.1.3 Manufacture, testing and approval procedure

7.1.3.1 Manufacturer's plant, production methods and quality control measures shall be such as to ensure reasonable uniformity in manufacture, see also Sec.1.

7.1.3.2 Testing and approval procedure shall be in accordance with Sec.1 and as required in Section 1 to 6 for the individual categories (types) of welding consumables mentioned in 7.1.1.2 above.

7.2 Testing of the weld metal

7.2.1 For testing the deposited weld metal, test pieces analogous to those called for in Sections 1 to 6 respectively shall be prepared, depending on the type of the welding consumables (and according to the welding process). The base metal used shall be a fine-gained structural steel compatible with the properties of the weld metal, or the side walls of the weld shall be buttered with a weld metal of the same composition.

7.2.2 The chemical composition of the deposited weld metal shall be determined and certified in a manner analogous to that prescribed in Sec.2, Cl.2.2.4. The results of the analysis shall not exceed the limit values specified in the standards or by the manufacturer, the narrower tolerances being applicable in each case.

7.2.3 Depending on the type of the welding consumables (and according to the welding process), the test specimens prescribed in Sections 1 to 6 respectively shall be taken from the weld metal test pieces in a similar manner.

7.2.4 The mechanical properties must meet the requirements stated in Table 7.2.1 and Table 7.2.2. The provisions of Sections 1 to 6 apply in analogous manner to the performance of the tests, including in particular the maintenance of the test temperature in the notched bar impact test and the carrying out of results.

7.2.5 Specifications of welding consumables used for welding high strength extremely thick steel plates of thickness more than 50 [mm] but not exceeding 100[mm] of EH47 grade used in container carriers are to be in accordance with Table 7.2.3

7.3 Testing on welded joints

7.3.1 Depending on the type of the welding consumables (and according to the welding process), the testing on the welded joints shall be performed on butt-weld test pieces in a manner analogous to that called for in Sections 1 to 6.

7.3.2 Depending on the type of the welding consumables (and according to the welding process), the butt-weld test pieces called for in para 7.3.1 shall be welded in a manner analogous to that prescribed in Sections 1 to 6. The base metal used shall be a high-strength fine-grained structural steel with an appropriate minimum yield strength and tensile strength and compatible with the added symbol for which application is made.

7.3.3 Depending on the type of the welding consumables (and according to the welding process), the test specimens described in Sections 1 to 6 shall be taken from the butt-weld test pieces.

7.3.4 The mechanical properties must meet the requirements stated in Table 7.3.1. The provisions of Sections 1 to 6 apply in analogous manner to the performance of the tests, including in particular the maintenance of the test temperatures in the notched bar impact test and the requirements regarding the retest specimens.

Table 7.2.1 : Required toughness properties of the weld metal

Quality Grade	Test temp.°C	Min. notch impact energy [J] 1)
3	- 20	Y42: ≥ 47 Y46: ≥ 47
4	- 40	Y50: ≥ 50 Y55: ≥ 55
5	- 60	Y62: ≥ 62 Y69: ≥ 69

1) Charpy V-notch impact test specimen, mean value of three specimens; for requirements regarding minimum individual values and retests, See Section 1

Table 7.2.2 : Required strength properties of the weld metal

Symbols added to quality grade	Min. yield strength or 0.2% proof stress [N/mm^2]	Tensile Strength 1) [N/mm^2]	Minimum elongation [%]
Y42	420	530 - 680	20
Y46	460	570 - 720	20
Y50	500	610 - 770	18
Y55	550	670 - 830	18
Y62	620	720 - 890	18
Y69	690	770 - 940	17

1) The tensile strength of the weld metal may be upto 10% below the requirements, provided that the results obtained with the transverse tensile specimens taken from the welded joints meet the minimum tensile strength requirements stated in Table 7.3.1. The elongation is to be stated in the test report.

Note: For welding very large plate thicknesses where the "supporting effect" of the base material on either side of the weld no longer applies and the tensile strength of the weld metal also determines the tensile strength of the welded joint, it may be necessary, when applying footnote 1), to chose welding consumables of the next higher strength category (next higher added symbol).

Table 7.2.3 : Required strength properties for deposited metal used to weld high strength extremely thick steel plates of thickness more than 50[mm] but not exceeding 100[mm], of EH47 grade used in container carriers,

Mechanical Properties			Impact Test	
Yield Strength [N/mm^2] min.	Tensile Strength [N/mm^2]	Elongation (%) min	Test Temp. [^{o}C]	Average Impact Energy [J] min.
460	570/720	19	-20	53

7.3.5 Where the bending angle required in Table 7.3.1 is not achieved, the specimen may be considered as fulfilling the requirements, if the bending elongation on a gauge length Lo fulfills the minimum elongation requirements stated in Table 7.2.2. The gauge length Lo = Ls + t (Ls = width of weld, t = specimen thickness), see Fig.7.3.1.

7.3.6 Mechanical Properties for Butt weld tests for high strength extremely thick steel plates of thickness more than 50[mm] but not exceeding 100[mm], of EH47 grade used in container carriers are to be as per Table 7.3.2

Table 7.3.1 : Required properties of welded joints

Quality Grade	Added symbol	Min. tensile strength [N/mm^2]	Min. notch impact energy, test temperature	Minimum bending angle [1]	Bend ratio D/t [2]
3 to 5 in accordance with Table 7.2.1	Y42 Y46 Y50 Y55 Y62 Y69	530 570 610 670 720 770	Depending on the quality grade and yield strength in accordance with Table 7.2.1	120°	4 4 4 5 5 5

1) Bending angle attained before the first incipient crack, minor pore exposures upto a maximum length of 3 mm allowed.

2) D = Mandrel diameter, t = specimen thickness

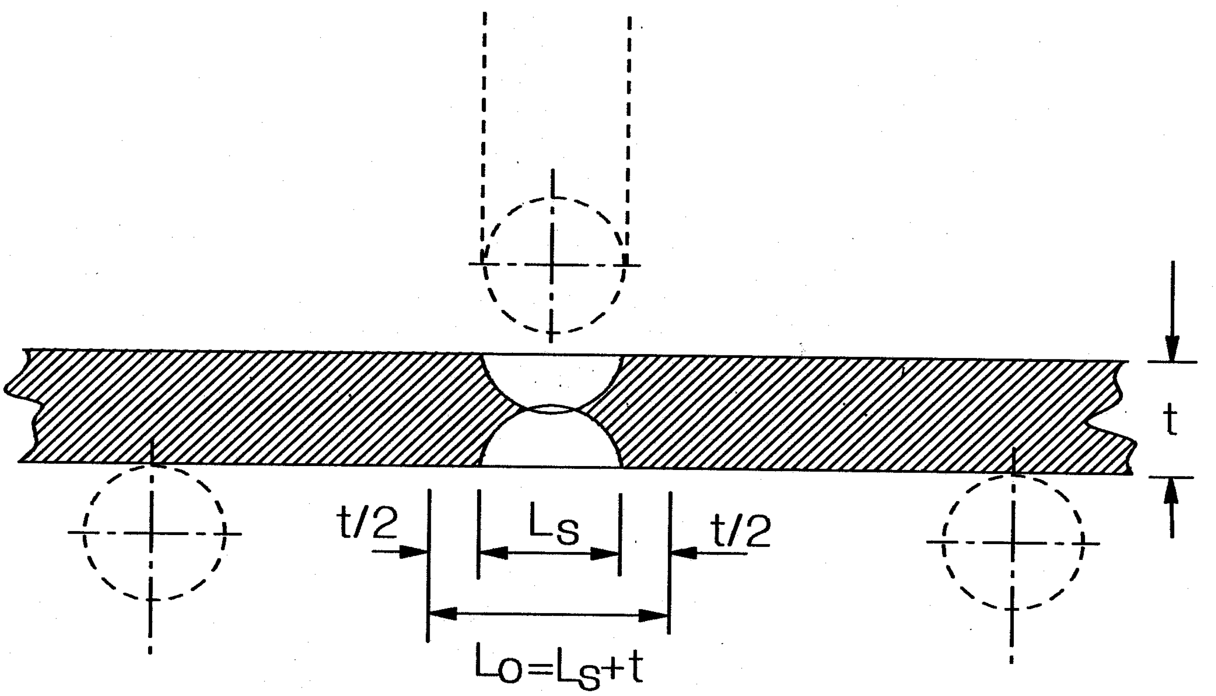


Fig.7.3.1 : Required proportion of welded joints

Table 7.3.2 : Mechanical Properties for Butt weld tests for high strength extremely thick steel plates of thickness more than 50[mm] but not exceeding 100[mm], of EH47 grade used in container carriers

Tensile Strength [N/mm^2]	Bend Test Ratio: D/t	Charpy V-notch Impact Tests		
		Test Temperature (^{o}C)	Average Energy (J) min.	
			Downhand, horizontal-vertical, overhead	Vertical (Upward and Downward)
570-720	4	-20	53	53

7.4 Hydrogen test

7.4.1 The welding consumables, other than solid wire-gas combinations, shall be subjected to a hydrogen test in accordance with the mercury method to ISO 3690, or any other method such as the gas chromatographic method which correlates with that method, in respect of cooling rate and delay times during preparation of the weld samples, and the hydrogen volume determinations.

7.4.2 The diffusible hydrogen content of the weld metal determined in accordance with the provisions of Sec.2, Para 2.5 shall not exceed the limits given in Table 7.4.1.

Table 7.4.1 : Allowable diffusible hydrogen content

Yield strength group	Hydrogen symbol	Max. hydrogen content [cm^3/100 g deposited weld metal]
Y42 Y46 Y50	H 10 (HH)	10

7.5 Annual tests

7.5.1 The annual repeat tests specified in Sections 1 to 6 shall entail the preparation and testing of weld metal test pieces as prescribed under 7.2. In special cases, IRS may require more extensive tests.

Section 8

Consumables for Welding of Aluminium Alloys

8.1 General

8.1.1 Tests for the approval of consumables intended for welding the aluminium alloys detailed in Ch.9 are to be carried out generally in accordance with the requirements of Secs.1,2 and 5, except as otherwise detailed in this Section.

8.1.2 The welding consumables are divided into two categories as follows:

W = wire electrode, wire - gas combinations for metal arc inert gas welding (MIG, 131 according to ISO 4063), tungsten inert gas welding (TIG, 141) or plasma arc welding (15)

R = rod - gas combinations for tungsten inert gas arc welding (TIG, 141) or plasma arc welding (15)

8.1.3 Approval will be indicated by the grade as shown in Table 8.1.3.

Table 8.1.3 : Consumables grades and base materials for the approval test

Consumable quality grade (Symbol)	Base material for the tests	
	Alloy Designation	
	Numerical	Chem-Symbol
RA/WA	5754	AlMg3
RB/WB	5086	AlMg4
RC/WC	5083	AlMg4.5 Mn0.7
	5383	AlMg4.5 Mn0.9
	5456	AlMg5
	5059	-
RD/WD	6082	AlSi1MgMn
	6005A	AlSiMg(A)
	6061	AlMg1SiCu
Note: Approval on higher strength AlMg base materials covers also the lower strength AlMg grades and their combination with AlSi grades		

8.1.4 The welding technique will be indicated in the approval grading by a letter as under:

m - manual multi-run welding (GTAW);
S - semi-automatic multi-run welding (GMAW);
M - automatic multi-run welding (GTAW or GMAW);
T - automatic two-run welding (GMAW).

8.1.5 The compositions, of the shielding gas and the filler/electrode wire are to be reported.

8.1.6 Approval of a wire or a rod will be granted in conjunction with a specific shielding gas according to Table 8.1.6 or defined in terms of composition and purity of "special" gas to be designated with group sign "S". The composition of the shielding gas is to be reported. Where a wire in combination with any particular gas has been approved, usage of the same wire with another gas in the same group as defined in Table 8.1.6 may be considered.

Table 8.1.6 : Compositional limits of shielding gases and mixtures to be used

Group	Gas composition (Vol.%)[1])	
	Argon	Helium
I - 1	100	-
I - 2	-	100
I - 3	Rest	> 0 to 33
I - 4	Rest	> 33 to 66
I - 5	Rest	> 66 to 95
S	Special gas, composition to be specified, See 8.1.6	

1) Gases of other chemical composition (mixed gases) may be considered as "special gases" and covered by a separate test.

8.1.7 On completion of welding, assemblies must be allowed to cool naturally to ambient temperature. Welded test assemblies and test specimens must not be subjected to any heat treatment after welding except for the alloy Grades 6005A, 6061 and 6082. These are to be

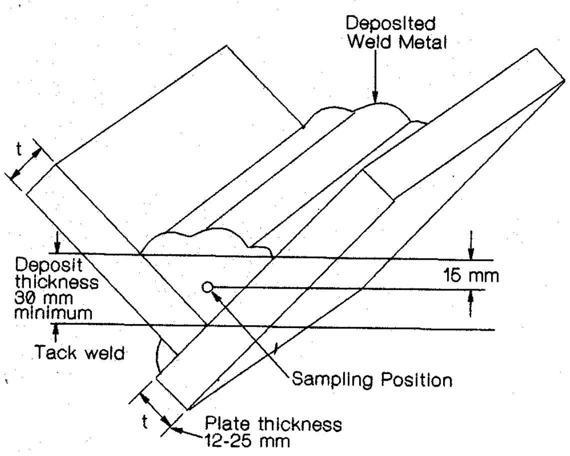


Fig.8.3.1 : Deposited metal test assembly

allowed to naturally age at ambient temperature for a period of 72 hours from the completion of welding, before the testing is carried out. A second solution heat treatment is not permitted. The time and temperature of any ageing treatment is to be reported in detail.

8.2 Initial approval tests for manual, semi-automatic and automatic multi-run techniques

8.2.1 Plate of the corresponding type of aluminium alloy and of appropriate thickness is to be used for the preparation of the weld test assemblies.

8.2.2 The welding current and power requirements are to be within the range recommended by the manufacturer and are to be reported.

8.2.3 Welded assemblies are to be prepared and tested in accordance with 8.3, 8.4 and 8.5.

8.3 Deposited metal test assemblies

8.3.1 One assembly is to be prepared in the downhand position as shown in Fig.8.3.1.

8.3.2 The chemical composition of the plate used for the assembly is to be compatible with the weld metal.

8.3.3 The thickness of the plate used and the length of the assembly are to be appropriate to the welding process. The plate thickness is to be not less than 12 [mm].

8.3.4 For the approval of filler wire/gas and electrode wire/gas combinations for manual or semi-automatic welding by GTAW or GMAW, one test assembly is to be welded using any size of wire within the range for which approval is sought.

8.3.5 For automatic multi-run approval, one test assembly is to be welded by the respective process using the recommended diameter of wire.

8.3.6 The weld metal is to be deposited in multi-run layers in accordance with normal practice. The direction of deposition of each layer is to alternate from each end of the plate.

8.3.7 The deposited weld metal in each test assembly is to be analysed and reported including the contents of all significant elements.

The elements reported will be dependent on the type of aluminium alloy for which approval of the consumables is requested. The results of the analysis are to be within the tolerances specified in the standards and by the manufacturer.

8.4 Butt weld test assemblies

8.4.1 Plate of the corresponding type of aluminium alloy and of an appropriate thickness is to be used for the preparation of the test assemblies.

Table 8.4.1 : Requirements for the transverse tensile and bend tests

Grade	Base material used for the test	Tensile strength R_m [N/mm^2] min.	Former diameter	Bending angle 1) [°] min.
RA/WA	5754	190	3t	
RB/WB	5086	240	6t	
RC/WC	5083	275		
	5383 or 5456	290	6t	180
	5059	330		
RD/WD	6061, 6005A or 6082	170	6t	

1) During testing, the test specimen shall not reveal any one single flaw greater than 3 [mm] in any direction. Flaws appearing at the corners of a test specimen shall be ignored in the evaluation, unless there is evidence that they result from lack fusion.

8.4.2 In order to ensure sound and representative welds, it is essential that test assemblies are cleaned and degreased prior to welding. Assemblies as shown in Fig.8.4.2 are to be prepared for each welding position (downhand, horizontal-vertical, vertical-upward, vertical-downward and overhead) for which the consumable is recommended by the manufacturer; except that consumables satisfying the requirements for downhand and vertical-upward positions will be considered as also complying with the requirements for the horizontal-vertical position.

Back sealing runs are allowed in single V weld assemblies. In case of double V assembly both sides shall be welded with the same welding position.

8.4.3 One additional assembly, as shown in Fig.8.4.3, is to be prepared for welding in the downhand position. The assembly is to be welded using, for the first run, wire of the smallest diameter recommended by the manufacturer and for the remaining runs, wire of the largest diameter to be approved.

8.4.4 The manufacturer's recommended procedures are to be used in making the welds and are to be reported.

8.4.5 The welded assemblies should be subjected to both radiographic and visual examination, aided where necessary by dye penetrant testing, to ensure that the welds are free from cracks and porosity.

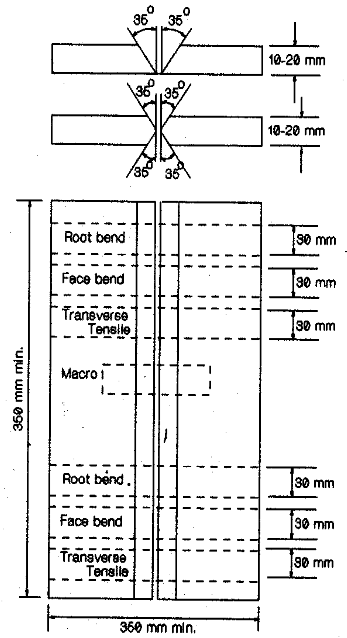


Fig.8.4.2 : Butt weld test assembly (positional welding)

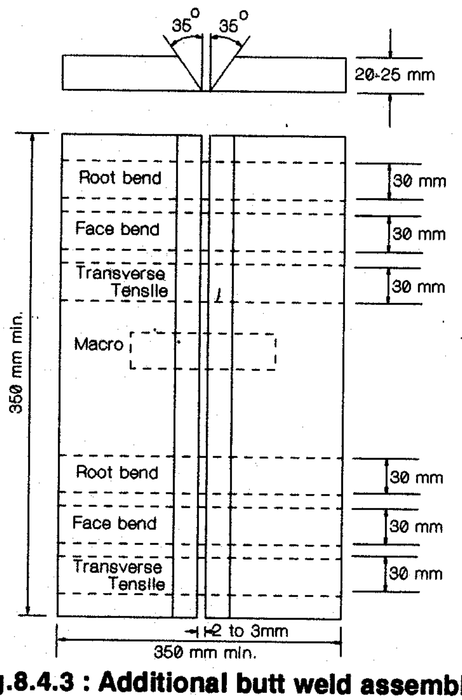


Fig.8.4.3 : Additional butt weld assembly (downhand)

8.4.6 The test specimens are to be taken from the welded assemblies as shown in Fig.8.4.2 and Fig.8.4.3. For each assembly they are to comprise:

2 transverse tensile specimens;
1 macro specimen;
2 face bend specimens; and
2 root bend specimens.

8.4.7 All tensile test specimens should have a tensile strength not less than the respective value shown in Table 8.4.1. The position of each fracture is to be reported.

8.4.8 The bend test specimens are to be bent around a former having a diameter not more than the number of times the thickness (t) of the test specimen as shown in Table 8.4.1.

8.5 Fillet weld test assemblies

8.5.1 Assemblies are to be prepared and tested in accordance with the appropriate requirements of 2.4 except that the plates are to be of the aluminium alloy for which approval is required, that no hardness tests are required and that for automatic multi-run approval only one fillet weld bead is to be made using the recommended wire diameter. In this case, the bead size should be as large as the maximum single bead size recommended by the manufacturer for fillet welding.

8.5.2 The results of examination of the macro specimens and the fractured fillet welds are to be reported in accordance with 2.4.3 and 2.4.5. Particular attention is to be given to the presence of any porosity.

8.6 Initial approval tests for two-run technique

8.6.1 Two butt weld test assemblies are to be prepared using the following plate thicknesses as shown in Fig.8.7.1:

a) one with the maximum thickness for which approval is requested;

b) one with a thickness approximately one half to two thirds that of the maximum thickness.

8.7 Annual tests

8.7.1 Annual repeat tests are to consist of preparation and testing of the deposited weld metal test assembly as prescribed in 8.3 (Fig.8.3.1) and of the downhand buttweld assembly according to 8.4 (Fig.8.4.2).

End of Chapter

Rules and Regulations for the Construction and Classification of Steel Ships

Part 3

General Hull Requirements

July 2016

IRCLASS

Indian Register of Shipping

Indian Register of Shipping

Part 3

General Hull Requirements

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Chapter 1

General, Definitions, Documentation

Contents

Section 1

General

1.1 Scope

1.1.1 The Rules in this part apply to all-welded, single hull sea going steel ships of normal form, proportions and speed.

1.1.2 For additional class notations relating to various ship types, requirements as per Pt.5 are to be complied with.

1.1.3 Ships of unconventional forms and proportions or intended for carriage of cargoes not covered by the Rules or to be engaged in special service will receive individual consideration based on the general principles of the Rules. In these cases, however, additional calculations and/or model testing may be required to be carried out and submitted for approval.

1.1.4 Proposals for use of alternative materials e.g. aluminium, wood, etc. for some parts of the ship shall receive special consideration.

1.2 Equivalence

1.2.1 Alternative arrangements, scantlings and equipment may be accepted provided they can be shown to be equivalent to the overall safety and strength standard of the Rules. Direct calculations for the derivation of the scantlings as an alternative to those derived by the Rule formulae, may be accepted on special consideration. The calculation procedure and the assumptions made are to be submitted for approval.

1.3 National and international regulations

1.3.1 While the Rules cover requirements for the classification of ships, the attention of all concerned is drawn to requirements of various local, national or international Regulations, Codes and Recommendations which the vessel may also have to comply with.

1.4 Stability

1.4.1 All ships will be assigned class only after it has been demonstrated that their intact stability and damage stability (where applicable) are in compliance with the standards laid down by the National Statutory Authority.

The level of intact stability for ships with a length of 24 [m] and above in any case is not to be less than that required by Part A of the International Code on Intact Stability, 2008 (IMO Resolution MSC 267(85), as amended) as applicable to the type of ship being considered.

Damage stability requirements in IMO instruments as listed in 1.4.3 are also to be complied with, as applicable to the type and size of ship.

Where other criteria for stability are accepted by the Administration concerned, these criteria may be used for the purpose of classification.

Where the Administration has not specified criteria of stability for ships of less than 24 [m] in length, appropriate criteria for the type of ship may be applied which is acceptable to IRS.

1.4.2 For pontoons of all sizes, in case the Administration concerned has not laid down criteria for intact stability, it is recommended that the criteria indicated below or equivalent are satisfied:

- Ch.2, Sec 2.2 of Part B of the International Code on Intact Stability, 2008 (Resolution MSC 267(85)).

1.4.3 All ships are required to comply with the applicable damage stability requirements in accordance with the following:

a) Part B and Part B-1 through B-4 of Chapter II-1 of SOLAS 1974 as adopted by IMO Resolution MSC 216(82) for passenger ships regardless of length and cargo ships having load line length "L_L" of 80 [m] and above.

   Cargo ships which are shown to comply with any other damage stability regulations indicated in the following (1.4.3 b) to g)) are excluded from the applicability of the above.

b) Regulation 27 of ILLC 1966 as applied to tankers and dry cargo vessels in compliance with Resolutions A.320(IX) and A.514(13) provided that in the case of ships to which regulation 27(9) applies, main transverse watertight bulkheads, to be considered effective, are spaced according to paragraph 12(f) of resolution A.320(IX). Compliance with Reg.27 of ILLC Protocol 1988 is accepted as equivalent to the above.

   In case ships for which Reg.27 of ILLC applies are intended to carry deck cargo also, then a limiting GM or KG curve is to be provided to the master in the stability manual based on compliance with the probabilistic damage stability analysis of SOLAS Chapter II-1 Part B-1. In such cases the KG used for demonstrating compliance with the deterministic damage stability requirements of ILLC Reg.27 should be same as that used for the probabilistic damage stability calculations required by SOLAS Ch.II-1 Part B-1 at the deepest subdivision loadline.

c) Annex I (Regulation 28) of MARPOL 1973/78, for Oil Tankers except that combination carriers with Type B freeboard are not excluded.

d) IBC Code, as amended for Chemical Tankers in general.

e) IGC Code, as amended for Liquefied Gas Carriers.

f) Resolution MSC 235(82) for Offshore Supply Vessels.

g) Resolution MSC 266(84) for Special Purpose Ships.

1.4.4 An approved stability information manual is to be available on board for guidance to the master as to the stability of the ship under varying conditions of service. This is to be prepared on the basis of MSC Circular 920 "Model Loading and Stability Manual".

Additionally, full details of the stability criteria appropriate to the ship under all anticipated conditions of service are to be clearly stated in text supplemented by diagrams using the nomenclature adopted in the manual. Full details of any requirements for wind and/or wave forces and ice accretion specified by the Administration are also to be provided.

1.5 Damage control plan and booklet for dry cargo and passenger ships

1.5.1 **Plan** : The damage control plan is to include inboard profile, plan views of each deck and transverse sections to the extent necessary to show the following:

- the watertight boundaries of the ship;

- the locations and arrangements of cross-flooding systems and any other system for correction of list;

- the locations of all internal watertight closing appliances including on ro-ro ships, internal ramps or doors and their controls, position indicators, alarms and special precautions required, if any, for the closing appliances during voyage;

- the locations of all doors in the shell of the ship, position indicators, leakage detection and surveillance devices;

- the locations of all weathertight closing appliances in local subdivision boundaries above the bulkhead deck and on the lowest exposed weather decks, together with locations of controls and position indicators, if applicable;

- the locations, arrangement and control positions of the entire bilge and ballast system.

1.5.2 **Booklet** : The damage control booklet is to contain aforementioned information as in the plan and in addition general instructions for controlling the consequential effects of damage as follows:

- shutting off the closing appliances;
- ensuring the safety of personnel onboard;
- ascertaining extent of damage and rates of flooding by sounding;
- cautionary advise regarding causes of any list; required liquid transfer operations to lessen list or trim and the resulting effects of additional free surfaces;
- initiating pumping operations to control the ingress of water;

The booklet should provide:

- details of sounding devices, tank vents and overflows;
- pump capacities and piping diagrams;
- operating procedure of cross-flooding system;
- locations of non-watertight openings with non-automatic closing devices through which progressive flooding can occur;
- details of access and means of escape for personnel to and from compartments;
- procedure for alerting ship management and other organisations for obtaining and co-ordinating assistance;

1.5.3 For passenger ships, the plan is to be permanently exhibited on the navigating bridge, as well as in the ship's control station, or equivalent.

1.5.4 For cargo ships the plan is to be permanently exhibited or readily available on the navigating bridge and in the cargo control room, where applicable.

1.6 Protective location of fuel oil tanks

1.6.1 All ships with an aggregate oil fuel capacity of 600 [m^3] and above are to satisfy the requirements for oil fuel tank protection as given in MARPOL Reg.I/12A. For this purpose, the distances of the oil fuel tanks above the bottom shell and inboard of the side shell are to be not less than the values specified in the above MARPOL Regulation.

Alternatively, such ships may comply with the accidental oil outflow performance standard specified in paragraph 11 of MARPOL Reg. I/12A.

1.6.2 Small oil fuel tanks of capacity not greater than 30 [m^3] are exempted from the requirements for protective location of the above MARPOL Regulation provided the aggregate capacity of such exempted tanks is not greater than 600 [m^3].

1.7 Assumptions

1.7.1 It is assumed that significant dynamic excitation of major orders from propellers and machinery do not fall close to any natural frequency of the hull.

1.7.2 It is assumed that the ships will be competently handled and loaded as per the approved loading manuals.

Section 2

Definitions

2.1 Principal particulars

2.1.1 The forward perpendicular, F.P., is the perpendicular drawn at the intersection of the summer load water line with the fore side of the stem.

In ships with unusual bow arrangement the position of the F.P. will be specially considered.

2.1.2 The after perpendicular, A.P., is the perpendicular drawn at the intersection of the summer load waterline with the after side of the rudder post or the centreline of the rudder stock if there is no rudder post.

In ships with unusual stern arrangement the position of the A.P. will be specially considered.

2.1.3 Rule length, L, is the distance, [m], between the forward and after perpendiculars. However L is to be not less than 96 per cent, and need not be greater than 97 per cent of the extreme length on the summer load waterline.

In ships with unusual bow and/or stern arrangement the Rule length, L, will be specially considered.

2.1.4 "Amidship" is at 0.5L aft of the F.P.

2.1.5 Breadth, B, is the greatest moulded breadth [m].

2.1.6 Depth, D, is the moulded depth [m], measured amidships from top of the keel to the moulded deck line of the uppermost continuous deck at side. When a rounded gunwale is arranged the depth is to be measured to the continuation of the moulded deck line.

2.1.7 Draught, T, is the moulded draught amidships corresponding to the summer load waterline, [m].

2.1.8 The block co-efficient, Cb, is the moulded block co-efficient calculated as follows :-

$$C_b = \frac{\text{moulded displacement } [\text{m}^3] \text{ at draught } T}{LBT}$$

2.1.9 Load line length, L_L , is to be taken as 96 per cent of the total length [m], on a waterline at 85 per cent of the least moulded depth measured from the top of the keel, or as the length from the fore side of the stem to the axis of the rudder stock on that waterline, if that is greater. In ships designed with a rake of keel, the waterline on which this length is measured is to be parallel to the designed waterline.

2.1.10 Speed, V, is the maximum service speed in knots on draught T.

2.2 Structural terms

2.2.1 The general terms used in the Rules for various structural parts of the ships are defined as under:

- *Strength Deck* : In general the uppermost continuous deck. Where a superstructure deck has within 0.4L amidships, a continuous length equal to or greater than (1.5B + 3H), it is to be regarded as the strength deck instead of the covered part of the uppermost continuous deck. (H is the height of the superstructure, [m]).

- *Freeboard Deck* : The freeboard deck is normally the uppermost complete deck exposed to weather and sea, which has permanent means of closing all openings in the weather part and below which all openings on the sides of the ship are fitted with means for watertight closing.

- *Superstructure* : A decked structure on freeboard deck extending from side to side of the ship or with the side plating not inboard of shell plating by more than 4 per cent of the breadth B.

- *Deckhouse* : A decked structure above the freeboard deck with the side plating being inboard of the shell plating by more than 4 per cent of the breadth B.

- *Bottom Structure* : Shell plating with stiffeners and girders below the upper turn of bilge and all other elements below and including the inner bottom plating in case of the double bottom. Sloping hopper tank top is to be regarded as a bulkhead.

- *Side Structure* : Shell plating with stiffeners and girders between the upper turn of bilge and the uppermost continuous deck at side. A rounded gunwale is included in the side structure.

- *Deck Structure* : Deck plating with stiffeners, girders, and supporting pillars.

- *Girder* : A collective term for the primary supporting members, other terms include :

  - Transverses - transverse girders under the deck.

  - Web frames - side vertical girders.

  - Hatch end beams - transverse deck girders at the ends of the hatch.

  - Stringers - horizontal girders.

  - Cross-ties - girders connecting two vertical girders in a deep tank.

  - Floor - bottom transverse girders.

- *Stiffener* : A collective term for secondary supporting members; other terms being :

  - Frames.

  - Bottom, inner bottom, side or deck longitudinals.

  - Reverse frame - transverse stiffener on the inner bottom.

  - Horizontal or vertical bulkhead stiffeners.

- Other terms are defined in the appropriate Chapters.

2.3 Material factor

2.3.1 Material factor, k, a factor depending on material strength is defined in Ch.2.

Section 3

Documentation

3.1 General

3.1.1 Documentation is to be submitted as per the following paragraphs. In case of certain ship types additional documentation may be required as per Pt.5.

3.1.2 The documents should be submitted in triplicate, one copy of which shall be returned.

3.2 Plans for information

3.2.1 The following supporting plans and calculations are to be submitted for information :

- General arrangement.

- Tank plan.

- Capacity plan.

- Lines plan and Hydrostatic curves or tables.

- Docking plan.

3.3 Additional information

3.3.1 The following additional information is to be submitted as necessary for strength calculations:

- Maximum values of still water bending moments and shear forces.

- Lightship weight and its longitudinal distribution.

- Bonjeans data.

- Stowage factor and angle of repose of bulk cargoes to be carried.

- Masses and unbalanced moments of heavy machinery components e.g. engines, cranes, winches etc.

3.4 Plans for approval

3.4.1 Plans as relevant are to be submitted for approval as indicated in Table 3.4.1. These should as far as practicable be complete in all necessary details.

3.5 Plans to be kept on board

3.5.1 A set of as built construction drawings and other plans showing any subsequent structural alterations are to be kept on board. The set of plans are to include the following:

a) Main plans

- i) General arrangement
- ii) Capacity plan
- iii) Hydrostatic curves
- iv) Loading manual, where required

b) Structural plans

- i) Midship section
- ii) Scantling profile
- iii) Decks
- iv) Shell expansion
- v) Transverse bulkheads
- vi) Rudder and rudder stock
- vii) Cargo hatch covers, when applicable

c) Bilge ballast and cargo piping diagrams.

An additional set of such drawings are to be kept ashore by the company responsible for the operation of the ship.

3.5.2 To facilitate the ordering of materials for repairs, the above plans are to show the disposition and extent of high strength steel and steel of grades other than Grade A, along with the information relating to their physical and mechanical properties, recommended working, treatment and welding procedures etc.

3.5.3 A ship construction file is required to be maintained on board the ship to facilitate inspection (survey) and repair and maintenance in future.

The ship construction file to contain :

a) Plans as mentioned at 3.5.1;

b) Essential certificates and records;

c) Manuals required for classification and statutory requirements;

d) Details of equipment forming part of the watertight and weathertight integrity of the ship;

e) Tank testing plan including details of the test requirements;

f) Corrosion protection specifications;

g) Details for the in-water survey, if applicable, information for divers, clearances measurements instructions etc. tank and compartment boundaries;

h) Docking plan and details of all penetrations normally examined at drydocking;

i) Coating technical file, for ships subject to compliance with the IMO Coating Performance Standard (PSPC). (See Part 3, Chapter 2, Section 3.6).

Table 3.4.1 : Plans for approval

Plan	**Including Information On**
Loading manual [1)]	details of loading in all contemplated loading conditions and resulting SWBM, SF and Torsional Moments (TM) design values of SWBM, SF & TM
Midship section Other transverse sections Longitudinal sections & decks Shell expansion & framing plan Pillar arrangements Wash bulkheads	main particulars (L, B, D, T, C_b, V) equipment specification complete class notation applied for spacing of stiffeners Density of cargo Standard construction details deck loads, if other than those specified in the Rules openings on the deck minimum ballast draught(s) extent of flat part of bottom forward openings on the shell Flat of bottom, flat of side material grades
Double bottom	indication of access height and location of overflows loading on inner bottom
Watertight subdivision bulkheads & watertight tunnels	openings and their closing appliances
Plan of water tight doors	Electrical diagram of power control and position indication circuits.
Plan of weather tight or outer doors and hatchways	-
Aft-end structure Stern frame or sternpost Propeller shaft brackets Aft peak tank	propeller outline propeller thrust structural details in way of rudder and propeller bearings height and location of overflow
Engine room structure Engine and thrust block seatings	type, power and r.p.m. of propulsion machinery weight of machinery, boilers, etc.
Transverse thruster, if any, general arrangement, tunnel structure, connections of thruster with tunnel and hull structures.	-
Fore-end construction Fore peak tank	openings on non-watertight bulkheads and diaphragm plates height and location of overflows
Oil tight/water tight and partition bulkheads in cargo tanks, ballast tanks and deep tanks	intended tank contents & their densities height and location of overflow/air pipes tanks intended to be partially filled corrosion protection; if any
Superstructures, deckhouses and machinery castings	height of sills from deck and closing appliances for companionways Extension and mechanical properties of the aluminum alloy used (where applicable)
Bulwarks and freeing ports	Arrangements and dimensions of bulwarks and freeing ports on the freeboard deck and the superstructure deck.
Windows and side scuttles,	arrangement and details
Scuppers and sanitary discharges	-
Hatchways Hatch covers Bow & stern doors Side ports	position and type loads if different from those specified in the rules sealing and securing arrangement, spacing of bolts or wedges Distance of hatch covers from summer load waterline and from fore end.

Table 3.4.1 : (Contd.)

Plan	**Including Information On**
Rudder, stock and tiller Steering gear arrangement	speed of the ship (head & astern) material of bearings, coupling bolts, stock and the locking device rudder carrier
Supporting structure and foundations for ship board fitting associated with mooring and towing operations.	Design loads and directions of load actions, rated pull and holding load for mooring winches Reaction forces Details of connection of the foundations to the deck, including specifications for holding down bolts for mooring winches Material specifications and welding
Supporting structure and foundations for windlasses and chain stoppers.	Design loads and directions of load actions Reaction forces Details of connection of the foundations to the deck, including specifications for holding down bolts for windlasses Material specifications and welding
Plan for access to and escape from spaces	-
Plan for ventilation including ventilators and tank vents	Use of spaces and location and height of air vents outlets of various compartments.
Masts & derrick posts Support structure for masts, derrick posts & cranes	derrick length and loading dimensions and positions of stays and shrouds quality of material maximum sea state in offshore operation, if any connections to hull structure
Supporting structure for life saving appliances	Design loads, SWL and self weight, connections to hull structure.
Bilge keel	material grade details of connection to hull structure
Testing plan of tanks & bulkheads	Test procedure for various compartments Height of pipes for testing
Equipment number calculation	Geometric elements for calculation List of equipments Construction and breaking load of steel wires Material, construction, breaking load and relevant elongation of synthetic ropes
Anchoring arrangement	-
Mooring and towing arrangement	-
Welding details	

Note:

1) See Chapter 5, Section 6.
2) One drawing may contain more than one of the items from each group.
3) Where other steering or propulsion systems are adopted (eg. Steering nozzles or azimuth propulsion systems), the plans showing the relevant arrangement and structural scantlings are to be submitted.
4) The information is to be included as indicated in the 2nd column are required for approval of plans given in the 1st column of the Table. However, approval of plans mentioned in the 1st column does not necessarily mean that all the information given in 2nd column are also approved or need approval.

End of Chapter

Chapter 2

Materials of Construction

Contents

Section 1

General

1.1 Scope

1.1.1 The Rules relate, in general, to the construction of steel ships. Consideration will however be given to the use of other materials also.

1.1.2 The materials used in the construction of the ship are to be manufactured and tested in accordance with the requirements of Pt.2. Materials for which provision is not made in Pt.2 may be accepted, provided that they comply with an approved specification and such tests as may be considered necessary.

1.2 Steel

1.2.1 Ordinary hull structural steel is a hull structural steel with a minimum yield stress of 235 [N/mm^2] and a tensile strength generally in the range of 400-490 [N/mm^2].

For ordinary hull structural steel, the **material factor `k'** is to be taken as 1.0.

1.2.2 Steels having a yield stress of 265 [N/mm^2] and higher, are regarded as higher tensile steels. Where higher tensile steel is used, the hull girder section modulus and the local scantlings may be reduced in accordance with the relevant requirement of the Rules. For this purpose, a material factor 'k', is to be taken as follows:

k = 0.78 for steel with a minimum yield stress of 315 [N/mm^2]

k = 0.72 for steel with minimum yield stress of 355 [N/mm^2]

k = 0.68 for steel with minimum yield stress of 390 [N/mm^2].

1.2.3 Where steel castings or forgings are used for sternframes, rudderframes, rudder stocks, propeller shaft brackets and other major structural items, they are to comply with Pt.2 as appropriate.

1.3 Aluminium

1.3.1 Where seawater resisting aluminium alloys manufactured and tested in accordance with the requirements of Pt.2 are used for super-structures, deckhouses, hatch covers, helicopter decks or other structural components, scantlings equivalent to steel are to be derived as follows:

plating thickness, $t_a = t_s \sqrt{k_a}$

section modulus of stiffeners, $Z_a = Z_s.k_a$

where,

t_a, t_s = plating thickness of aluminium and mild steel respectively.

Z_a, Z_s = section modulus of aluminium and mild steel stiffeners respectively.

$$k_a = \frac{235}{\sigma_a}$$

σ_a = 0.2% proof stress of the aluminium alloy in the welded condition or 70% of the ultimate strength in the welded condition, whichever is lesser [N/mm^2].

1.3.2 The smaller modulus of elasticity of aluminium is to be taken into account, when determining the buckling strength of structural elements subjected to compression and the deflections, where relevant.

Section 2

Use of Steel Grades

2.1 Grades of steel

2.1.1 The resistance to fracture is controlled, in part, by the notch toughness of the steel used in the structure. Steels with different levels of notch toughness are specified in Pt.2. The grade of steel to be used is, in general, related to the air temperature in the area of operation, thickness of the material and the stress pattern associated with its location.

2.1.2 The grades of steel to be used for structures of ships in normal world wide service and those exposed to low air temperatures ($\leq$ -20°C), are given in Sec 2.2 and 2.3 respectively. The grades of steel to be used for certain hull members in refrigerated spaces are given in Sec 2.4.

2.1.3 Where tee or cruciform connections employ full penetration welds, and the plate material is subject to significant strains in a direction perpendicular to the rolled surfaces, it is recommended that consideration be given to the use of special plate material with specified through thickness properties, as detailed in Pt.2.

2.2 Ships in normal world wide service

2.2.1 Materials in the various strength members are not to be of lower grade than those corresponding to material classes and grades specified in Tables 2.2.1a) to 2.2.1f) and Table 2.2.2.

General requirements are given in Table 2.2.1a), while additional minimum requirements are given in the following:

- Table 2.2.1b): For ships, excluding liquefied gas carriers covered in Table 2.2.1c), with length exceeding 150 [m] and single strength deck,
- Table 2.2.1c): For membrane type liquefied gas carriers with length exceeding 150[m].
- Table 2.2.1d): For ships with length exceeding 250[m],
- Table 2.2.1e): For single side bulk carriers subject to SOLAS regulation XII/6.4.3
- Table 2.2.1f) For ships with ice strengthening.

2.2.2 The material grade requirements for hull members of each class depending on thickness are defined in Table 2.2.2.

2.2.3 For strength members not mentioned in Tables 2.2.1a) to 2.2.1f), Grade A/AH may generally be used.

2.2.4 The steel grade is to correspond to the as-built plate thickness and material class.

2.2.5 Plating materials for stern-frames supporting the rudder and propeller boss, rudders, rudder horns and shaft brackets are in general not to be of lower grades than corresponding to Class II. For rudder and rudder body plates subjected to stress concentrations (e.g. in way of lower support of semi-spade rudders or at upper part of spade rudders) Class III is to be applied.

Table 2.2.1a) : Material classes and grades for ships in general

Structural member category	Material class/grade
SECONDARY:	
Longitudinal bulkhead strakes, other than that belonging to the primary category	- Class I within 0.4L amidships - Grade A/AH outside 0.4L amidships
Deck plating exposed to weather, other than that belonging to the primary or special category	
Side plating	
PRIMARY:	
Bottom plating, including keel plate	- Class II within 0.4L amidships - Grade A/AH outside 0.4L amidships
Strength deck plating, excluding that belong to the special category	
Continuous longitudinal plating of strength members above strength deck, excluding hatch coamings	
Uppermost strake in longitudinal bulkhead	
Vertical strake (hatch side girder) and uppermost sloped strake in top wing tank	
SPECIAL:	
Sheer strake at strength deck (1)	- Class III within 0.4L amidships - Class II outside 0.4L amidships - Class I outside 0.6L amidships
Stringer plate in strength deck (1)	
Deck strake at longitudinal bulkhead, excluding deck plating in way of inner skin bulkhead of double hull ships (1)	
Strength deck plating at outboard corners of cargo hatch openings in container carriers and other ships with similar hatch opening configurations	- Class III within 0.4L amidships - Class II outside 0.4L amidships - Class I outside 0.6L amidships - Min. class III within cargo region
Strength deck plating at corners of cargo hatch openings in bulk carriers, ore carriers combination carriers and other ships with similar hatch opening configurations Trunk deck and inner deck plating at corners of openings for liquid and gas domes in membrane type liquefied gas carriers	- Class III within 0.6L amidships - Class II within rest of cargo region
Bilge strake in ships with double bottom over the full breadth and length less than 150 m (1)	- Class II within 0.6L amidships - Class I outside 0.6L amidships
Bilge strake in other ships (1)	- Class III within 0.4L amidships - Class II outside 0.4L amidships - Class I outside 0.6L amidships
Longitudinal hatch coamings of length greater than 0.15L including coaming top plate and flange	- Class III within 0.4L amidships - Class II outside 0.4L amidships - Class I outside 0.6L amidships - Not to be less than Grade D/DH
End brackets and deck house transition of longitudinal cargo hatch coamings	
(1) Single strakes required to be of Class III within 0.4L amidships are to have breadths not less than 800+5L [mm], need not be greater than 1800 [mm], unless limited by the geometry of the ship's design.	

Table 2.2.1b) : Minimum material grades for ships with length exceeding 150 [m] and single strength deck

Structural member category	Material grade
Longitudinal plating of strength deck where contributing to the longitudinal strength	Grade B/AH within 0.4L amidships
Continuous longitudinal plating of strength members above strength deck	Grade B/AH within 0.4L amidships
Single side strakes for ships without inner continuous longitudinal bulkhead(s) between bottom and the strength deck	Grade B/AH within cargo region

Table 2.2.1c) : Minimum material grades for membrane type liquefied gas carriers with length exceeding 150[m]

<table>
<tr><th colspan="2">Structural member category</th><th>Material grade</th></tr>
<tr><td colspan="2">Longitudinal plating of strength deck where contributing to the longitudinal strength</td><td>Grade B/AH within 0.4L amidships</td></tr>
<tr><td rowspan="2">Continuous longitudinal plating of strength members above strength deck</td><td>Trunk deck plating</td><td>Class II within 0.4L amidships</td></tr>
<tr><td>• Inner deck plating
• Longitudinal strength member plating between the trunk deck and inner deck</td><td>Grade B/AH within 0.4L amidships</td></tr>
<tr><td colspan="3">Note: Table 2.2.1c) is applicable to membrane type liquefied gas carriers with deck arrangements as shown in Fig. 2.2.1. Table 2.2.1 c) may also apply to similar ship types with a “double deck” arrangement above the strength deck.</td></tr>
</table>

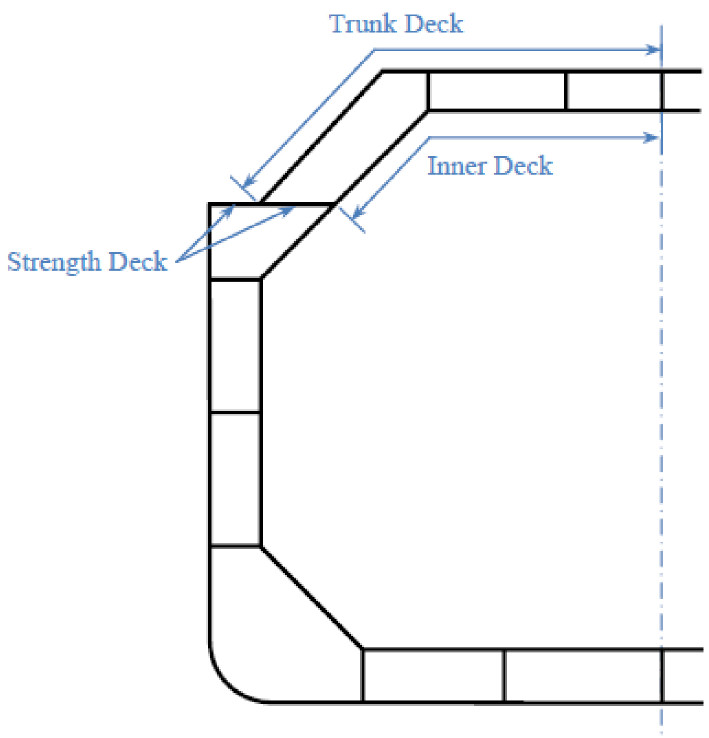


Fig. 2.2.1 Typical deck arrangement for membrane type Liquefied Natural Gas Carriers

Table 2.2.1d) : Minimum material grades for ships with length exceeding 250 [m]	
Structural member category	**Material grade**
Sheer strake at strength deck (1)	Grade E/EH within 0.4L amidships
Stringer plate at strength deck (1)	Grade E/EH within 0.4L amidships
Bilge strake (1)	Grade D/DH within cargo region
(1) Single strakes required to be of Grade E/EH and within 0.4L amidships are to have breadths not less than 800+5L [mm], need not be greater than 1800 [mm], unless limited by the geometry of the ship's design.	

Table 2.2.1e) : Minimum material grades for single-side skin bulk carriers subjected to SOLAS Regulation XII/6.4.3 (3)	
Structural member category	**Material grade**
Lower bracket of ordinary side frame (1), (2)	Grade D/DH
Side shell strakes included totally or partially between the two points located to 0.125*l* above and below the intersection of side shell and bilge hopper sloping plate or inner bottom plate (3)	Grade D/DH
(1) The term "lower bracket" means webs of lower brackets and webs of the lower part of side frames upto the point of 0.125 h above the intersection of side shell and bilge hopper sloping plate or inner bottom plate. (2) The span of the side frame, h, is defined as the distance between the supporting structures. See Fig 2.5.7 of Pt 5 Ch 1. (3) SOLAS Regulation XII/6.4.3 applies to bulk carriers of $L_L \geq 150$ [m], carrying solid bulk cargoes having a density of 1000 [kg/m^3] and above constructed on or after 1 July 2006.	

Table 2.2.1f) : Minimum material grades for ships with ice strengthening	
Structural member category	**Material grade**
Shell strakes in way of ice strengthening area for plates (See Part 5, Chapter 21)	Grade B/AH

Table 2.2.2 : Material grade requirements for classes, I, II and III

Class	**I**		**II**		**III**	
Thickness [mm]	**MS**	**HT**	**MS**	**HT**	**MS**	**HT**
$t \leq 15$	A	AH	A	AH	A	AH
$15 < t \leq 20$	A	AH	A	AH	B	AH
$20 < t \leq 25$	A	AH	B	AH	D	DH
$25 < t \leq 30$	A	AH	D	DH	D	DH
$30 < t \leq 35$	B	AH	D	DH	E	EH
$35 < t \leq 40$	B	AH	D	DH	E	EH
$40 < t \leq 50$	D	DH	E	EH	E	EH

2.3 Structures exposed to low air temperatures

2.3.1 For ships intended to operate in areas with low air temperatures (below and including -20°C), e.g. regular service during winter seasons to Arctic or Antarctic waters, the materials in exposed structures are to be selected based on the design temperature t_D as defined in 2.3.2.

2.3.2 The design temperature t_D is to be taken as the lowest mean daily average air temperature in the area of operation as illustrated in Fig.2.3.2.

Mean : Statistical mean over observation period (at least 20 years).

Average : Average during one day and night.

Lowest : Lowest during year.

MDHT = Mean Daily High (or maximum) Temperature

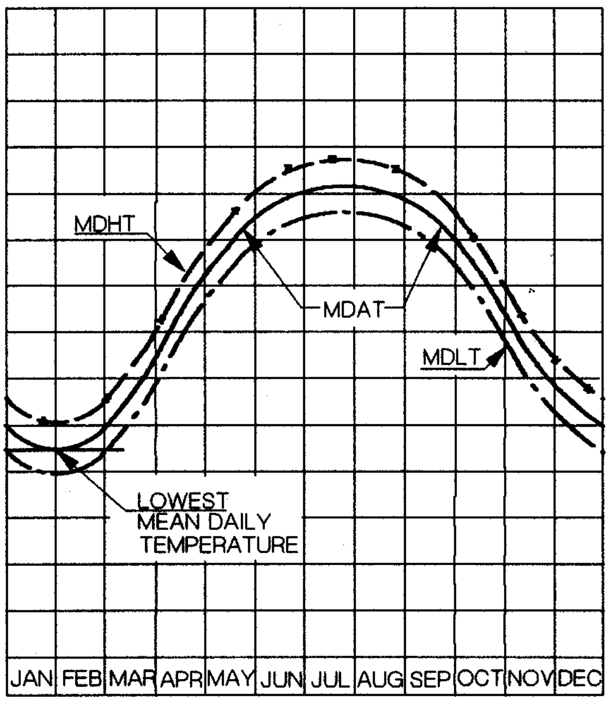
MDAT = Mean Daily Average Temperature

MDLT = Mean Daily Low (or minimum) Temperature.

For seasonally restricted service the lowest value within the period of operation would be applicable.

2.3.3 Materials in the various strength members above the lowest ballast water line (BWL) exposed to air are not to be of lower grades than those corresponding to classes I, II and III as given in Table 2.3.3, depending on the categories of structural members (SECONDARY, PRIMARY and SPECIAL). For non-exposed structures and structures below the lowest ballast water line, See 2.2.

2.3.4 The material grade requirements for hull members of each class depending on thickness and design temperature are defined in Table 2.3.5. For design temperatures t_D < -55°C, materials will be specially considered.



MDHT = Mean Daily High (or maximum) Temperature.
MDAT = Maen Daily Average Temperature.
MDLT = Mean Daily Low (or Minimum) Temperature.

Fig.2.3.2

Table 2.3.3 : Application of material classes and grades -
Structures exposed to low temperatures

	Material class/grade	
Structural member category	**Within 0.4L amidships**	**Outside 0.4L amidships**
SECONDARY: • Deck plating exposed to weather, in general • Side plating above BWL • Transverse bulkheads above BWL	I	I
PRIMARY: • Strength deck plating (see Note 1) • Continuous longitudinal members above strength deck, excluding longitudinal hatch coamings • Longitudinal bulkhead above BWL • Top wing tank bulkhead above NWL	II	I
SPECIAL: • Sheer strake at strength deck (see Note 2) • Stringer plate in strength deck (see Note 2) • Deck strake at longitudinal bulkhead (see Note 3) • Continuous longitudinal hatch coamings (see Note 4)	III	II

Notes:

1. Plating at corners of large hatch openings to be specially considered. Class III or grade E/EH to be applied in positions where high local stresses may occur.
2. Not to be less than grade E/EH within 0.4L amidships in ships with length exceeding 250 [m].
3. In ships with breadth exceeding 70 [m] at least three deck strakes to be class III.
4. Not to be less than grade D/DH.

Table 2.3.4 : Material grade requirements for classes I, II and III at low temperatures

Class I

Plate thickness [mm]	-20/-25°C		-26/-35°C		-36/-45°C		-46/-55°C	
	MS	**HT**	**MS**	**HT**	**MS**	**HT**	**MS**	**HT**
$t \leq 10$	A	AH	B	AH	D	DH	D	DH
$10 < t \leq 15$	B	AH	D	DH	D	DH	D	DH
$15 < t \leq 20$	B	AH	D	DH	D	DH	E	EH
$20 < t \leq 25$	D	DH	D	DH	D	DH	E	EH
$25 < t \leq 30$	D	DH	D	DH	E	EH	E	EH
$30 < t \leq 35$	D	DH	D	DH	E	EH	E	EH
$35 < t \leq 45$	D	DH	E	EH	E	EH	X	FH
$45 < t \leq 50$	E	EH	E	EH	X	EH	X	FH

Class II

Plate thickness [mm]	-20/-25°C		-26/-35°C		-36/-45°C		-46/-55°C	
	MS	**HT**	**MS**	**HT**	**MS**	**HT**	**MS**	**HT**
$t \leq 10$	B	AH	D	DH	D	DH	E	EH
$10 < t \leq 20$	D	DH	D	DH	E	EH	E	EH
$20 < t \leq 30$	D	DH	E	EH	E	EH	X	FH
$30 < t \leq 40$	E	EH	E	EH	X	FH	X	FH
$40 < t \leq 45$	E	EH	X	FH	X	FH	X	X
$45 < t \leq 50$	E	EH	X	FH	X	FH	X	X

Class III

Plate thickness [mm]	-20/-25°C		-26/-35°C		-36/-45°C		-46/-55°C	
	MS	**HT**	**MS**	**HT**	**MS**	**HT**	**MS**	**HT**
$t \leq 10$	D	DH	D	DH	E	EH	E	EH
$10 < t \leq 20$	D	DH	E	EH	E	EH	X	FH
$20 < t \leq 25$	E	EH	E	EH	X	FH	X	FH
$25 < t \leq 30$	E	EH	E	EH	X	FH	X	FH
$30 < t \leq 35$	E	EH	X	FH	X	FH	X	X
$35 < t \leq 40$	E	EH	X	FH	X	FH	X	X
$40 < t \leq 50$	X	FH	X	FH	X	X	X	X

Table 2.3.4 (Contd.)

Notes:

1. X = Not applicable.
2. Single strakes required to be of class III or of grade E/EH of FH are to have breadths not less than 800 + 5.L [mm] maximum 1800 [mm].
3. Plating materials for sternframes rudder horns, rudders and shaft brackets are not to be of lower grades than those corresponding to the material classes given in Sec.2.2.

2.4 Refrigerated spaces

2.4.1 Where the minimum design temperature of the steel falls below 0°C in refrigerated spaces, in addition to the requirements of 2.2.1, the grade of steel for the following items is to comply, in general, with the requirements of Table 2.4.1:

- Deck plating.
- Webs of deck girders.
- Longitudinal bulkhead strakes attached to deck.
- Shelf plates and their face bars supporting hatch covers.

2.4.2 Unless a temperature gradient calculation is carried out to assess the design temperature in the items defined in 2.4.1, the temperature to which the steel deck may be subjected is to be assessed as shown in Table 2.4.2.

Table 2.4.1 : Grades of steel for minimum design temperatures below 0°C

Min. design temp. in °C	Thickness, in mm	Grades of steel
0 to -10	$t \leq 12.5$ $12.5 \leq t \leq 25.5$ $t > 25.5$	B/AH D/DH E/EH
-10 to -25	$t \leq 12.5$ $t > 12.5$	D/DH E/EH
-25 to -40	$t \leq 12.5$ $t > 12.5$	E/EH C-Mn LT 60 or 1/2 Ni steels

Table 2.4.2 : Assessment of deck temperature

	Arrangement	Deck temperature
1)	Deck not covered with insulation in the refrigerated space	Temperature of the refrigerated space
2)	Deck covered with insulation in the refrigerated space and not insulated on the other side	Temperature of the space on the un-insulated side
3)	Deck covered with insulation on both sides	
	a) Temperature difference less than or equal to 11°C b) Temperature difference greater than 11°C but not greater than 33°C c) Temperature difference greater than 33°C	Mean of the temperatures of the spaces above and below the deck Mean of the temperatures of the spaces above and below the deck less 3°C Deck temperature will be specially assessed
Note: Where one of the internal spaces concerned is not refrigerated, the temperature of the space is to be taken as 5°C.		

Section 3

Corrosion Protection

3.1 General

3.1.1 All steelwork, except inside tanks intended for the carriage of oil or bitumen, is to be protected against corrosion by application of suitable coating.

For protection required in salt water ballast spaces, See 3.6.

For protection required in holds of dry bulk cargo carriers, see Pt.5, Ch.1, Sec. 2.11.

For the protection required in tanks carrying chemicals or other special cargoes, See Pt. 5, Ch.3.

3.1.2 Where bimetallic connections are made, measures are to be incorporated to preclude galvanic corrosion.

3.2 Surface preparation, prefabrication primers and paints or coatings

3.2.1 Steelwork is to be cleared of millscale and suitably cleaned before the application of surface paints and coatings. It is recommended that blast cleaning or other equally effective means be employed for this purpose.

3.2.2 Where a primer is used to coat steel after surface preparation and prior to fabrication, the composition of the coating is to be such that it will have no significant deleterious effect on subsequent welding work and that it is compatible with the paints or other coatings subsequently applied.

3.2.3 To determine the influence of the primer coating on the characteristics of welds, tests are to be made as detailed in 3.2.4 to 3.2.6.

3.2.4 Three butt weld assemblies are to be tested using plate material 20 to 25 [mm] thick. A 'V' preparation is to be used and, prior to welding, the surfaces and edges are to be treated as follows:-

a) Assembly 1 - Coated in accordance with the manufacturer's instructions.

b) Assembly 2 - Coated to a thickness approximately twice the manufacturer's instructions.

c) Assembly 3 - Uncoated.

3.2.5 Tests as follows are to be taken from each test assembly:-

a) Radiographs - These are to have a sensitivity of better than 2 per cent of the plate thickness under examination, as shown by an image quality indicator.

b) Photo-macrographs - These may be of actual size and are to be taken from near each end and from the centre of the weld.

c) Face and reverse bend test - The test specimens are to be bent by pressure or hammer blows round a former of diameter equal to 3 times the plate thickness.

d) Impact tests - These are to be carried out at ambient temperature, on three Charpy V-notch test specimens prepared in accordance with Pt.2. The specimens are to be notched at the centreline of the weld, perpendicular to the plate surface.

3.2.6 The tests are to be carried out in the presence of a Surveyor of IRS or by an independent laboratory specializing in such work. A copy of the test report is to be submitted, together with radiographs and macrographs.

3.2.7 Paints or other coatings are to be suitable for the intended purpose in the locations where they are to be used. Unless previously agreed, at least two coats are to be applied.

3.2.8 The paint or coating is to be compatible with any previously applied primer, See 3.2.2.

3.2.9 Paints, varnishes and similar preparations having a nitrocellulose or other highly flammable base, are not to be used in accommodation or machinery spaces.

3.2.10 In ships intended for the carriage of oil cargoes having a flash point below 60°C (closed cup test), paint containing aluminium should not in general be used in cargo tanks, adjacent ballast tanks, cofferdams, pump rooms as well as on deck above the mentioned spaces, nor in any other areas where cargo vapours may accumulate, unless it has been shown by appropriate tests that the paint to be used does not increase the incentive sparking hazard.

3.3 Internal cathodic protection

3.3.1 Impressed current cathodic protection systems are not permitted in any tank.

When a cathodic protection system is to be fitted in tanks for the carriage of liquid cargo with flash point not exceeding 60°C, a plan showing details of the locations and attachment of anodes is to be submitted. The arrangements will be considered for safety against fire and explosion aspects only.

3.3.2 Particular attention is to be given to the locations of anodes in relation to the structural arrangements and openings of the tank.

3.3.3 Anodes are to be of approved design and sufficiently rigid to avoid resonance in the anode support. Weldable steel cores are to be fitted, and these are to be so designed as to retain the anode even when the anode is wasted.

3.3.4 Anodes are to be attached to the structure in such a way that they remain secure both initially and during service. The following methods of attachment would be acceptable :

a) Steel core connected to the structure by continuous welding of adequate section.

b) Steel core bolted to separate supports, provided that a minimum of two bolts with lock nuts are used at each support. The separate supports are to be connected to the structure by continuous welding of adequate section.

c) Approved means of mechanical clamping.

3.3.5 Anodes are to be attached to stiffeners, or may be aligned in way of stiffeners on plane bulkhead plating, but they are not to be attached to the shell. The two ends are not to be attached to separate members which are capable of relative movement.

3.3.6 Where cores or supports are welded to the main structure, they are to be kept clear of the toes of brackets and similar stress raisers. Where they are welded to asymmetrical stiffeners, they are to be connected to the web with the welding kept at least 25 [mm] away from the edge of the web. In the case of stiffeners or girders with symmetrical face plates, the connection may be made to the web or to the centreline of the face plate but well clear of the free edges. However, it is recommended that anodes are not fitted to face plates of high strength steel longitudinals.

3.4 Aluminium and magnesium anodes

3.4.1 Aluminium and aluminium alloy anodes are permitted in oil cargo tanks and also in tanks adjacent to oil cargo tanks only at locations where the potential energy does not exceed 275 [J] (i.e. 28 [kgf m]). The weight of the anode is to be taken as the weight at the time of fitting, including any inserts and fitting devices.

3.4.2 The height of the anode is, in general, to be measured from the bottom of the tank to the centre of the anode. Where the anode is located on or closely above a horizontal surface (such as a bulkhead girder) not less than 1 [m] wide, provided with an upstanding flange or face plate projecting not less than 75 [mm] above the horizontal surface, the height of the anode may be measured above that surface.

3.4.3 Aluminium anodes are not to be located under tank hatches or tank cleaning openings unless protected by adjacent structure.

3.4.4 Magnesium or magnesium alloy anodes are not permitted in oil cargo tanks and in tanks adjacent to oil cargo tanks.

3.5 External hull protection

3.5.1 Suitable protection for the underwater portion of the hull is to be provided.

3.5.2 Where an impressed current cathodic protection system is fitted, plans showing the proposed layout of anodes, reference cells, wiring diagram and the means of bonding-in of the rudder and propeller, are to be submitted.

3.5.3 The arrangements for glands, where cables pass through the shell, are to include a small cofferdam. Cables to anodes are not to be led through tanks intended for the carriage of low flash point oils. Where cables are led through cofferdams or clean ballast tanks of tankers, they are to be enclosed in a substantial steel tube of about 10 [mm] thickness.

3.6 Corrosion protection coatings for salt water ballast spaces and double side skin spaces

3.6.1 The following spaces are to be coated during construction in accordance with the Performance Standards for Protective Coatings (PSPC) adopted by the IMO by Resolution

MSC.215(82), as per applicability indicated in 3.6.2.

a) Dedicated salt water ballast tanks in all ships of 500 GT and above.

b) Double side skin spaces in bulk carriers of $L_L \geq 150$ m.

The following tanks are not considered to be dedicated salt water ballast tanks and therefore need not comply with the requirement of IMO PSPC:

i) Salt water ballast tanks identified as “Spaces included in Net Tonnage” in the 1969 International Tonnage Convention Certificate;

ii) Salt water ballast tanks in passenger vessels also designated for the carriage of grey water.

3.6.2 The IMO Performance Standards for Protective Coatings (PSPC) are to be applied to ships as follows:

i) In case of bulk carriers and tankers that are subject to the IACS common structural rules:

- which are contracted for construction on or after 8 December, 2006.

ii) In case of all ships other than those mentioned in i) above:

- Which are contracted for construction on or after 1 July 2008, or
- In the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 January 2009, or
- The delivery of which is on or after 1 July 2012.

3.6.3 For oil tankers and bulk carriers constructed on or after 1 July 1998 and for which 3.6.1 and 3.6.2 are not applicable, the following are to be complied with:

a) All salt water ballast spaces are to have an efficient corrosion protection hard coating, epoxy or equivalent, applied in accordance with the manufacturer's requirements. The durability of the coatings could affect the frequency of survey of the spaces and light coloured coatings would assist in improving the effectiveness of subsequent surveys. It is therefore recommended that these aspects be taken into account by those agreeing to the specifications for the coatings and their application.

b) The scheme for the selection, application and maintenance of the coating system to follow the requirements of IMO Resolution A.798(19) and contain, as a minimum the following documentation:

- Owner’s, coating manufacturer’s and shipyard’s explicit agreement to the scheme for coating selection, application and maintenance.

- List of seawater ballast tanks identifying the coating system for each tank, including coating color and whether coating system is a hard coating.

- Details of anodes, if used.

- Manufacturer’s technical product data sheet for each product.

- Manufacturer’s evidence of product quality and ability to meet owner’s requirements.

- Evidence of shipyard’s and/or its subcontractor’s experience in coating application.

- Surface preparation procedures and standards, including inspection points and methods.

- Application procedures and standards, including inspection points and methods.

- Format for inspection reports on surface preparation and coating application.

- Manufacturer’s product safety data sheets for each product and owner’s, coating manufacturer’s and shipyard’s explicit agreement to take all precautions to reduce health and other safety risks which are required by the authorities.

- Maintenance requirements for the coating system.

3.7 Corrosion protection for Cargo Oil tanks of Crude Oil Tankers

3.7.1 Cargo oil tanks of crude oil tankers are to be :

i) Coated during construction in accordance with the Performance

Standards for Protective Coating (PSPC-COT) adopted by the IMO by Resolution MSC. 288(87). ; or

ii) Protected by alternative means of corrosion protection or utilization of corrosion resistance material to maintain required structural integrity for 25 years in accordance with the performance standard for alternative means of corrosion protection for cargo oil tanks of crude oil tankers, adopted by the IMO by Resolution MSC. 289(87).

3.7.2 The requirements given in 3.7.1 are to be applied for crude oil tanker greater than 5000 tonnes deadweight where :

i) Building contract is placed on or after 1st January 2013;

ii) In absence of building contract, the keels of which are laid or which are at a similar stage of construction on or after 1st July 2013;

iii) Or the delivery of which is on or after 1st January 2016.

3.7.3 The Administration may exempt a crude oil tanker from the requirements of 3.7.1 to allow the use of prototype alternatives to the coating system specified in 3.7.1 i), for testing, provided they are subject to suitable controls, regular assessment and acknowledgement of the need of immediate remedial action if the system fails or is shown to be failing. Such exemption is to be recorded on an exemption certificate.

3.7.4 The Administration may exempt a crude oil tanker from the requirement of 3.7.1 if the ship is built to be engaged solely in the carriage of cargoes and cargo handling operations not causing corrosion. Such exemption and conditions for which it is granted is to be recorded on an exemption certificate. (See MSC.1/Circ.1421 "Guidelines on exemption for crude oil tankers solely engaged in the carriage of cargoes and cargo handling operations not causing corrosion").

Section 4

Deck Covering

4.1 General

4.1.1 Where plated decks are sheathed with wood or an approved composition, reductions in plate thickness may be allowed.

4.1.2 The steel deck is to be coated with a suitable material in order to prevent corrosive action, and the sheathing or composition is to be effectively secured to the deck.

4.1.3 Deck coverings in the following positions are to be of a type which will not readily ignite where used on decks :

a) forming the crown of machinery or cargo spaces within accommodation spaces of cargo ships

b) within accommodation spaces, control stations, stairways and corridors of passenger ships.

End of Chapter

Chapter 3

Principles for Scantlings and Structural Details

Contents

Section 1

General

1.1 Application

1.1.1 Scantlings of various platings, stiffeners and girders to meet the local strength requirements are to be determined in accordance with the general principles given in this Chapter.

The design values of loads to be considered are given in Ch.4.

1.1.2 Scantlings of hull members contributing to the longitudinal strength are also to comply with the requirements of Ch.5.

1.1.3 Scantlings of hull members subjected to compressive stresses are also to comply with the requirements of Sec.6.

1.2 Symbols

p = design pressure [N/mm^2] as per Ch.4.

s = stiffener spacing [mm], measured along the plating.

l =span of the stiffener, [m], in accordance with 4.1.1.

r = radius of curvature [mm].

S = span of the girder [m], in accordance with 4.1.2.

b = mean breadth [m], of the load area supported by the girder.

h_W = height of web, [mm].

b_f = width of flange, [mm].

t_w, t_f = net thickness of web and flange [mm], respectively after deduction of t_c as given in 2.1.1. For bulb sections, t_f is to be based on the mean thickness of the bulb.

σ = allowable bending stress, [N/mm^2] as given in the relevant Chapters.

σy = minimum yield stress of material, [N/mm^2], may be taken as 235 [N/mm^2] for normal strength steel.

k = material factor as defined in Ch.2, Sec.1.2.

E = modulus of elasticity, 2.06 x 10^5 [N/mm^2] for steel.

1.3 Frame spacing

1.3.1 The normal frame spacing between aft peak and 0.2L from F.P. may be taken as:

450 + 2L [mm] for transverse framing

550 + 2L [mm] for longitudinal framing.
However, it is generally not to exceed 1000 [mm].

1.3.2 Elsewhere, the frame spacing is generally not to exceed the following:

- In peaks and cruiser sterns:

600 [mm] or as in 1.3.1, whichever is lesser.

- Between collision bulkhead and 0.2L from F.P.:

700 [mm] or as in 1.3.1, whichever is lesser.

1.3.3 Where the actual frame spacing is higher than that mentioned above, the minimum thicknesses of various structural members as given in the Rules may require to be increased.

Section 2

Corrosion Additions

2.1 General

2.1.1 The thickness of plates, stiffeners and girders in tanks for water ballast and/or cargo oil and in holds of dry bulk cargo carriers is to be increased by a corrosion addition 't_c' as given in Table 2.1.1.

2.1.2 The required corrosion addition 'Zc' to the section modulus of stiffeners and girders due to the thickness addition 't_c' mentioned above may be approximated as:

$$Z_c = \frac{t_c h_w (b_f + 0.3 h_w)}{1000} \ [\mathrm{cm}^3]$$

Table 2.1.1 : Corrosion addition t_c [mm]

Item	Space Category	Vertical Surfaces		Horizontal Surfaces	
		Standard	Min-max.	Standard	Min-max.
Internal members within and plate boundary between spaces of the given category	Ballast tank	0.1 t_n	2-3 [1a)]	0.15 t_n	2-4 [1a)]
	Cargo oil tank only	0.1 t_n	2-3	0.15 t_n	2-4
	Hold of dry bulk cargo carriers	0.2 t_n	2.5[4] - 3.5	0.2 t_n	2.5[4] - 3.5
Plate boundary between the two given space categories	Ballast tank/Cargo oil tanks only	0.1 t_n	2-3 [1a)]	0.15 t_n	2-4 [1b)]
	Ballast tank/Hold of dry bulk cargo carrier	0.15 t_n	2-3	0.15 t_n	2-4
	Ballast tank/Other category space	0.05 t_n	0.5 - 1.0 [1c)]	0.1 t_n	2-3
	Cargo oil tank only/Other category space	0.05 t_n	0.5 - 1.0	0.1 t_n	2-3
	Hold of dry bulk cargo carrier/Other category space	0.1 t_n	1.5 - 2.0	0.1 t_n	1.5 - 2.0

Notes:

1 Where the relevant ballast or liquid cargo tanks extend upto the exposed weather deck, the minimum corrosion addition in the region extending upto 1.5 [m] below the weather deck is also to be not less than that indicated below against the symbols 1a, 1b, 1c used in the table.
1a) 3.0 [mm] 1b) 2.0 [mm] 1c) 2.0 [mm]

2 t_n = net plate thickness required [mm].

3 The term ballast tank also includes combined ballast and cargo oil tanks, but not cargo oil tanks which may carry water ballast on exceptional circumstances according to Regulation 13(3) of MARPOL 73/78.

4 Hold of dry bulk cargo carriers refers to the cargo holds of vessels with class notations **BC-A, BC-B, BC-C** or **Ore Carrier**. For single skin bulk carriers of length ≥ 150 [m], t_c min = 3.5 [mm].

5 Other category space denotes the hull exterior and all spaces other than water ballast and cargo oil tanks and holds of dry bulk cargo carriers.

Section 3

Plating

3.1 General

3.1.1 Minimum requirements of thickness of various platings are given in relevant chapters.

3.1.2 The thickness 't' of plating subjected to lateral pressure is not to be less than

$$t = f_a f_r \frac{s\sqrt{p}}{2\sqrt{\sigma}} + t_c \ \text{[mm]}$$

where,

f_a = correction factor for aspect ratio of plate field;

$$= \sqrt{1.10 - 0.5(s/1000\ l)^2};$$

however, not to be taken more than 1.0.

f_r = correction factor for curvature perpendicular to the stiffeners

= (1 - 0.5 s/r)

3.1.3 Any tapering of thickness of platings contributing to the longitudinal strength is to be based upon linear variation of stress σ allowed at specified regions.

Section 4

Stiffeners and Girders

4.1 Determination of span

4.1.1 For stiffeners, the span 'l' [m] is to be taken as the length of the stiffener between the two supporting members less the depth of stiffener on crossing panel if any. Where brackets larger than those required in 5.1.2 are fitted, the span may be determined as shown in Fig.4.1.1.

For curved stiffeners, 'l' may be based on the chord length.

4.1.2 For girders, the span 'S' [m] is to be taken as the length of the girder between the two supporting members, less the web height of in-plane girder if any, and the correction for bracket 'b_c', as shown in Fig.4.1.2.

4.2 Effective width of attached plating

4.2.1 The area of the attached plating, to be used in the calculation of sectional properties of the stiffeners and girders, is to be taken as the cross-sectional area within the effective width of the attached plating.

4.2.2 The effective width of plating attached to a stiffener may be taken as the mean of spacings on either side of the stiffener.

4.2.3 The effective width of plating attached to a girder, 'b_e' is to be taken as per the following:

b_e = c. b

where,

c = c_1, for girders with uniformly distributed loads or with six or more evenly spaced point loads

= c_2, for girders with three or less evenly spaced point loads.

Table 4.2.3 : Values of "c"

a/b	0.5	1.0	2.0	3.0	4.0	5.0	6.0	≥7.0
C_1	0.19	0.38	0.67	0.84	0.93	0.97	0.99	1.00
C_2	0.11	0.22	0.40	0.52	0.65	0.73	0.78	0.80

For intermediate values of a/b and number of point loads, values of 'c' may be obtained by interpolation.

a = span of the girder, for simply supported girders, [m].

= 60 per cent of span of the girder, for girders fixed at both ends, [m].

4.2.4 In case of girders on corrugated bulkheads which run across the corrugations, the effective width of attached plating is to be taken as 10% of that obtained from 4.2.3.

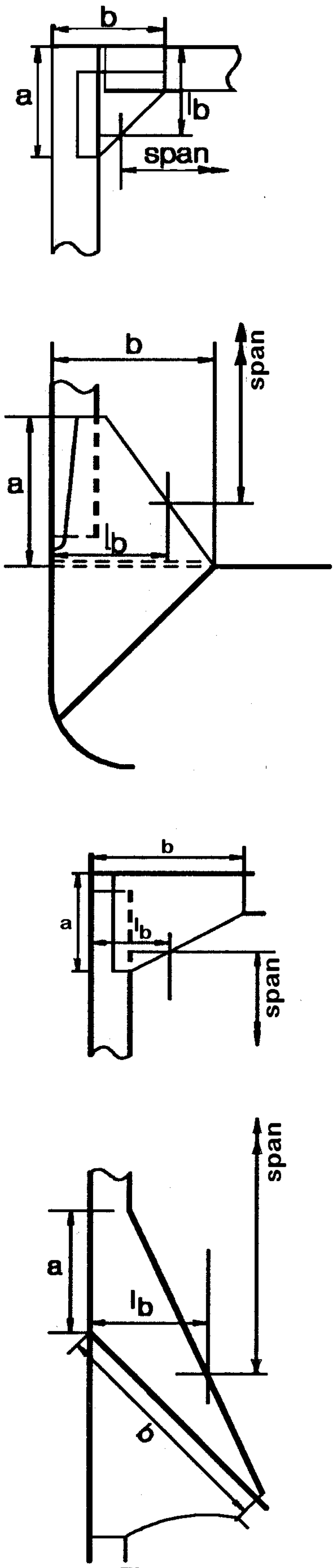
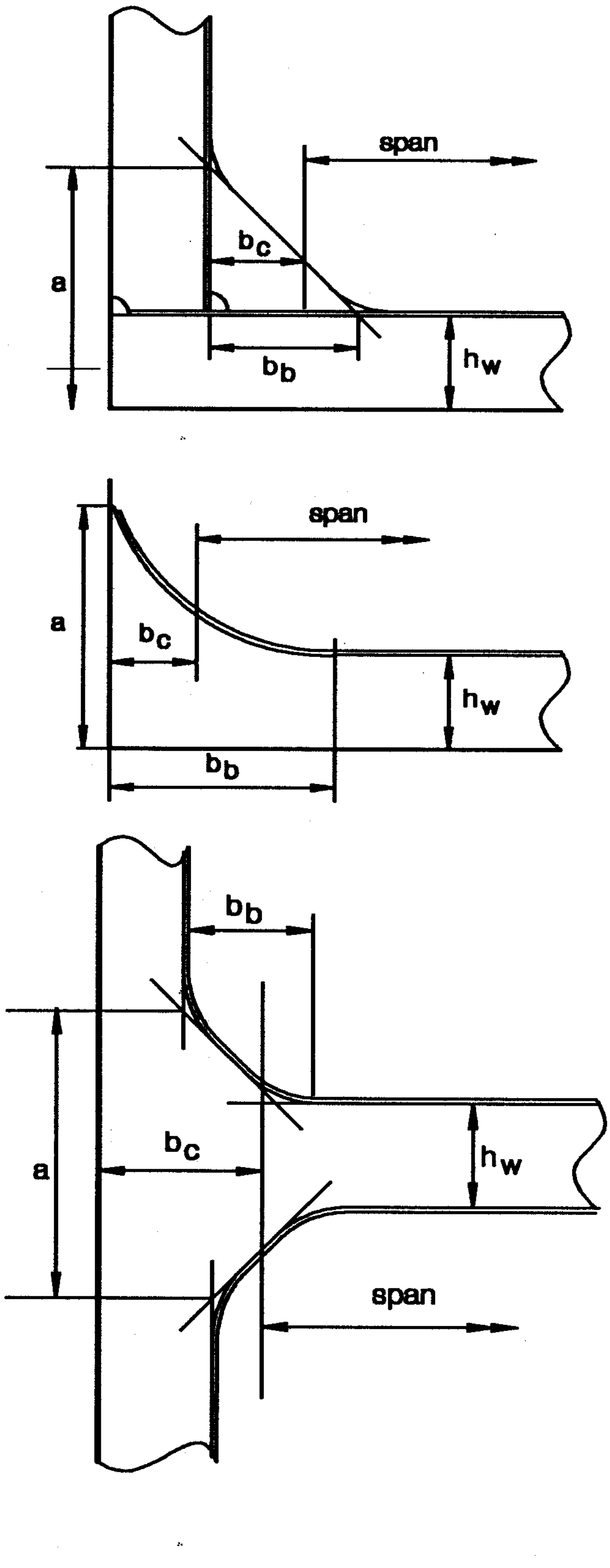


Fig.4.1.1



$$b_c = b_b\,(1 - h_w/a)$$

Fig.4.1.2

4.2.5 The effective cross sectional area of the attached plating is not to be less than that of the face plate.

4.3 Scantlings of stiffeners

4.3.1 The section modulus 'Z' of stiffeners subjected to lateral pressure is not to be less than:

$$Z = \frac{s.p.l^2.10^3}{m\sigma} + Z_c \ [cm^3] \text{ or } 15\ [cm^3]$$

whichever is greater.

where,

m = bending moment factor depending on the arrangement at the supports and variation of lateral pressure as given in the relevant chapters. Where not stated, the `m' value may generally be taken as:

= 12 for continuous longitudinal stiffeners.

= 10 for transverse, vertical and non-continuous longitudinal stiffeners fixed at both ends.

= 8 for stiffeners simply supported at both ends.

4.3.2 Where stiffeners are not perpendicular to the plating, the section modulus as obtained from 4.3.1 is to be increased by the factor (1/cos α), α being the angle between the stiffener web and the plane perpendicular to the plating.

4.4 Scantlings of girders

4.4.1 The scantlings of simple girders subjected to lateral pressure which can be considered as conforming to the general beam theory are to satisfy the requirements given in 4.4.2 and 4.4.3.

4.4.2 The section modulus 'Z' of girders subjected to lateral pressure is not to be less than:

$$Z = \frac{b.p.S^2.10^6}{m\sigma} + Z_c \ [cm^3]$$

where,

m = bending moment factor depending upon the arrangement at supports and variation of lateral pressure as given in the relevant chapters. Where not stated, the 'm' value may generally be taken as 12 for continuous longitudinal girders and 10 for all other girders.

4.4.3 The effective cross sectional area of the girder web is to be taken as :

$$A_W = 0.01\ h_n\ t_W \ [cm^2]$$

where,

h_n = net girder height, [mm], after deduction of cutouts at the section under consideration.

Where an opening is located at a distance less than $h_W/3$ from the cross section under consideration, h_n is to be taken as the smaller of the net height and the distance through the opening (h_{n1} + h_{n2}) (See Fig.4.4.3).

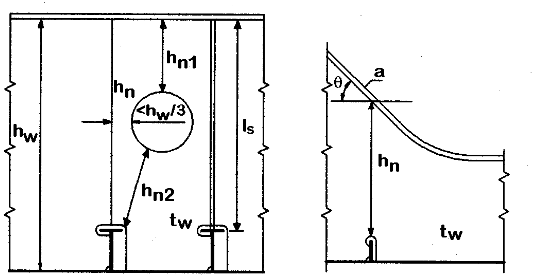


Fig.4.4.3 : Effective web area of girders

Where the girder flange is at angle θ to the length of the girder, A_w may be taken as:

$A_W = 0.01\ h_n\ t_W + 1.3\ a\ \text{Sin}\ 2\theta\ \text{Sin}\ \theta\ [cm^2]$

where,

a = area of flange, [cm^2]

The requirement of effective web area of various girders are given in the relevant Chapters.

4.4.4 The thickness of the girder web t_w is not to be less than:

$t_w = (6 + 0.02L) + t_c$ [mm] or

$t_w = \frac{S_w}{55} + t_c$ [mm], whichever is greater.

where,

S_w = web depth or spacing [mm], of the first web stiffener parallel to the face plate. In case of deep girders, value of S_w may be taken as 90% of the actual spacing.

The web stiffeners may be flat bars of same thickness as that of the web and 1/10 of the height of girder, in depth.

4.4.5 Where openings are cut in the girder web, they are to be away from the girder ends and scallops for stiffeners; with their centre located as near to the neutral axis of the girder as practicable. Openings of depth exceeding 25% of the girder depth or 300 [mm] and, of length exceeding the depth of the girder or 60% of the secondary stiffener spacing, are to be reinforced all around at the edge; or alternatively by providing horizontal and vertical stiffeners.

4.4.6 Girders are to be provided with adequate lateral stability by tripping brackets fitted generally at every alternate stiffener in case of asymmetrical section or at every fourth stiffener in case of symmetrical section. Tripping brackets are also to be fitted at the toes of end brackets and in way of concentrated loads such as heels of pillars or cross ties.

Where the width of face plate on one side of the web exceeds 15 t_f, the tripping brackets are to be connected to the face plate.

The tripping brackets are to be adequately dimensioned at base and are to have a smooth transition to the adjoining stiffeners. The free edge of the tripping bracket is to be stiffened if it's length exceeds 60t [mm]. Additional stiffeners are to be fitted parallel to the free edge to ensure that the arm length of an unstiffened triangular end panel does not exceed 100t [mm].

Section 5

End Attachments

5.1 End attachments of stiffeners

5.1.1 All stiffeners participating in the longitudinal strength are generally to be continuous over transverse members within 0.5L amidships. Proposals of longitudinals abutting at transverse members may be accepted outside 0.5L amidships region and in ships less than 150 [m] in length, provided the brackets connecting the ends of the longitudinals are continuous and of adequate size.

5.1.2 Scantlings of brackets fitted on stiffeners not participating in the longitudinal strength are not to be less than the following:

- The arm lengths, 'a and b' (See Fig.4.1.1) are to be such that:

i) a, b ≥ 0.8 l_b

and

ii) a+b ≥ 2.0 l_b

where,

$l_b = 24\sqrt{Z} + 75$ [mm]

- Thickness of unflanged bracket is to be not less than:

$$t = (4.0 + 0.3\sqrt{Z})\ \sqrt{(k_b/k_s)} + t_c\ \ [mm]$$

- Thickness of flanged bracket is to be not less than:

$$t = (3.0 + 0.25\sqrt{Z})\ \sqrt{(k_b/k_s)} + t_c\ \ [mm]$$

but need not be taken greater than 13.5 [mm]

- Width of flange, w ≥ 40 + Z/25 [mm], but not to be less than 50 [mm].

where,

Z is the section modulus [cm^3], of the smaller stiffener, being connected.

k_b, k_s are the material factors for the bracket and the stiffener, respectively.

5.2 End attachments of girders

5.2.1 The end attachments and supporting structure of the girders are to provide adequate resistance against rotation and displacement of the joint and effective distribution of the load from the member. Supporting members to which the girders are being connected, may require additional strengthening to provide adequate stiffness to resist rotation of the joint. Where the end attachment provides only a low degree of restraint against rotation, the girder is generally to be extended beyond the point of support by at least two frame spaces before being gradually tapered.

Connections between girders forming a ring system are to be such as to minimize stress concentrations at the junctions. Integral brackets are generally to be radiused or well rounded at the toes.

Where the face plate of the girder is not continuous over the bracket, the free edge of the bracket is to be stiffened and the face plate of the girder is to be extended well beyond the toe of the bracket.

5.2.2 The thickness 't' of brackets on girder is not to be less than that of the girder web.

The arm length 'a' including the depth of girder is not to be less than:

$$a = 83\sqrt{(Z/t)}\ \text{[mm]};$$

where,

Z = the section modulus [cm^3], of the girder to which the bracket is connected.

The cross sectional area 'A_f' of the face plate on the girder bracket is not to be less than:

$$A_f = 0.001\ l_f\ t\ [\text{cm}^2]$$

where, l_f is the length [mm], of the free edge of the bracket.

Additional stiffeners parallel to the bracket face plate are to be fitted on webs of large brackets. The arm length of an unstiffened triangular end panel of bracket is generally not to exceed 100t [mm].

5.3 Bracketless end connections

5.3.1 Two member connection

5.3.1.1 The thickness (t_b) of the common web at the joint of two member bracketless connection (Fig 5.3.1) is not to be less than the greater of the following:

$$t_b = \left(\frac{\sigma_1 A_1}{h_2} - t_2\tau_2\right)\frac{k}{110} \qquad [mm]$$

$$t_b = \left(\frac{\sigma_2 A_2}{h_1} - t_1\tau_1\right)\frac{k}{110} \qquad [mm]$$

and also, t_b is not to be less than t_1 and t_2

where,

A_1, A_2 = minimum required flange area of member 1 and 2 respectively [mm^2]

h_1, h_2 = web height of member 1 and 2 respectively [mm]

t_1, t_2 = minimum required thickness of web of member 1 and 2 respectively [mm]

τ_1, τ_2 = average shear stress in member 1 and 2 respectively [N/mm^2]

σ_1, σ_2 = bending stress at flange area of member 1 and 2 respectively [N/mm^2]

k = material factor for common web at corner as given in Pt. 3 Ch.2 Sec. 1.2.

5.3.1.2 Bending and shear stress computation is to be carried out by considering each member separately as a beam with appropriate boundary conditions. The corner joint between the members is to be considered as fixed joint.

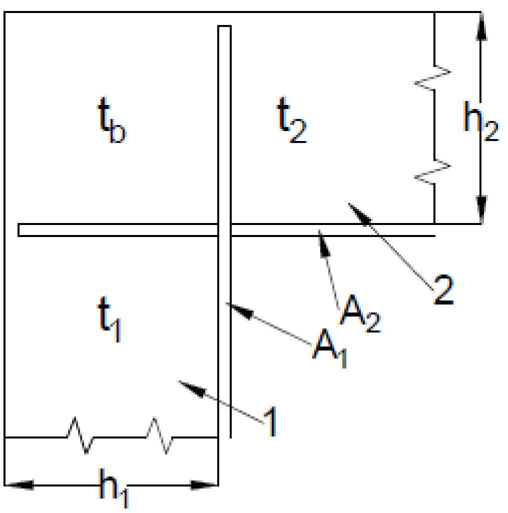


Fig.5.3.1 Bracketless end connection for two members

5.3.2 Three Member Connection

5.3.2.1 In the case of three member bracketless connection, when the flanges of member 1 and member 3 are continuous (Fig. 5.3.2), the thickness (t_b) of the common web at the joint is not to be less than the following:

$$t_b = \left(\frac{\sigma_2 A_2}{h_1} - t_1 \tau_1\right)\frac{k}{110} \qquad [mm]$$

and also, t_b is not to be less than t_1 and t_2.

5.3.2.2 In the case of three member bracketless connection, when the flanges of member 1 and member 3 are not continuous, the thickness (t_b) of the common web at the joint is to be determined as given by 5.3.1.1 and 5.3.1.2.

5.3.3 When the web height of member 1 and member 2 is more than $100t_b$, the common part of the corner web is to be stiffened.

5.3.4 Welding of the extended face plates of the joining members to the common web at the corner is to be of sufficient length and size to transfer the axial loads from the face plates to the common web.

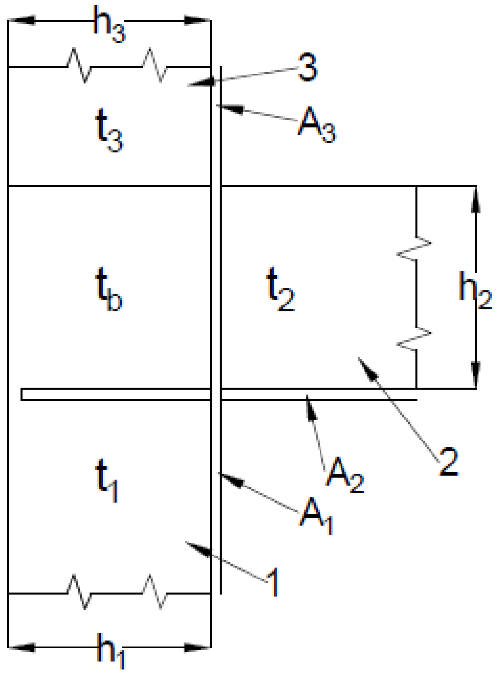


Fig.5.3.2 Bracketless end connection for three members

Section 6

Buckling

6.1 General

6.1.1 The critical buckling stress 'σ_{cr}' of plate panels and stiffeners and other members to compressive loads is to be such that:

$$\sigma_{cr} \geq \frac{\sigma_c}{\eta}$$

where,

σc = compressive stress to be considered as per Sec.6.3

η = 1.0 for deck, longitudinally stiffened side shell and single bottom plating

η = 0.9 for bottom, inner bottom plating in double bottom and transversely stiffened side shell plating

= 1.0 for local plate panels where an extreme load level is applied (e.g. impact pressure)

= 0.8 for local plate panels where a normal load level is applied

= 0.85 for lateral buckling mode of longitudinals

= 0.9 for torsional and web buckling mode of longitudinals

$$= \frac{0.7}{1 + l_m/i}$$ (need not be taken smaller than 0.3);

- for axially loaded members such as pillars, cross-ties, panting beams etc., in general. - to be reduced by 15 per cent where the loads are primarily dynamic in nature.

- for 'l_m' and 'i' See 6.2.6.

6.1.2 The critical compressive buckling stress 'σ_{cr}' may be determined as follows :

$$\sigma_{cr} = \sigma_E \quad \text{when} \quad \sigma_E \leq 0.5\,\sigma_y$$

$$= \sigma_y \left(1 - \frac{\sigma_y}{4\sigma_E}\right) \text{when}\, \sigma_E > 0.5\sigma_y$$

where,

σ_E = ideal elastic buckling stress as per Sec.6.2.

6.1.3 The critical shear stress of plate panels, stiffeners and other members to be such that

$$\tau_{cr} \geq \tau_c/\eta$$

where,

τ_c = Actual shear stress calculated for the plate panels

The shear stresses in plate panels of side shell and longitudinal bulkheads are given in Ch.5, Sec.4.2.

η = 0.90 for ship's side and longitudinal bulkhead subject to hull girder shear forces

= 0.85 for local panels in girder webs when nominal shear stresses are calculated (τ_c = Q/A)

= 0.90 for local panels in girder webs where shear stresses are determined by finite element calculation.

6.1.4 The critical shear buckling stress, 'τ_{cr}' may be determined as follows:

$$\tau_{cr} = \tau_E \quad \text{when} \quad \tau_E \leq 0.5\,\tau_y$$

$$= \tau_y \left(1 - \frac{\tau_y}{4\tau_E}\right) \text{when}\, \tau_E > 0.5\,\tau_y$$

where,

τ_E = ideal elastic shear buckling stress [N/mm^2], as per 6.2.2.

τ_y = yield stress in shear of the material [N/mm^2] = $\sigma_y/\sqrt{3}$.

6.2 Ideal elastic buckling stress

6.2.1 The σ_E value for platings may be taken as:

$$\sigma_E = 0.9\,K\,E\left[(t - t_c)/s\right]^2 \ [\text{N/mm}^2]$$

where,

$$K = \frac{8.4}{\Psi + 1.1}$$

- for plating with stiffeners in the direction of the compressive stress

$$= C\left[1 + \left(\frac{s}{1000\,l}\right)^2\right]^2 \ \frac{2.1}{\Psi + 1.1}$$

- for platings with stiffeners in the direction perpendicular to the compressive stress

ψ = ratio between the smaller and the larger values of the compressive stress assuming a linear variation (See Fig.6.2.1)

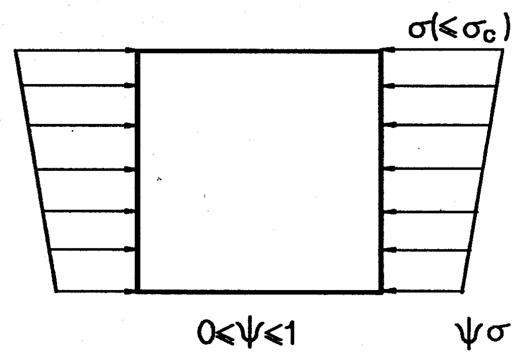


Fig.6.2.1

C = 1.30 when plating is stiffened by floors or deep girders

= 1.21 when stiffeners are angles or T sections

= 1.10 when stiffeners are bulb flats

= 1.05 when stiffeners are flat bars

s = shorter side of plate panel, [mm]

l = longer side of plate panel, [m]

6.2.2 The ideal elastic buckling stress for plate panels in shear may be taken as:

$\tau_E = 0.9\,K_s\,E\,[(t - t_c)/s]^2$ [N/mm^2]

where,

$K_s = 5.34 + 4\,(s/1000\,l)^2$

6.2.3 The value for the lateral buckling mode of longitudinals may be taken as:

$\sigma_E = 0.001\ E\ I_a / (A.l^2)$ [N/mm²]

where,

I_a = moment of inertia [cm⁴], of the longitudinal about the neutral axis parallel to the plating

A = cross sectional area [cm²], of the longitudinal

In the calculation of I_a and A, attached plating area corresponding to the longitudinal spacing and net thickness is to be included.

6.2.4 The σ_E value for the torsional mode of longitudinals may be taken as:

$$\sigma_E = \frac{\pi^2 E I_w}{10^4 I_p l^2}\left(m^2 + \frac{K}{m^2}\right) + 0.385 E \frac{I_t}{I_p} [\mathrm{N/mm^2}]$$

where,

$$K = \frac{C l^4}{\pi^4 E I_w} 10^6$$

m = number of deformation half waves depending on K, as per Table 6.2.4.

I_t = St Venant's moment of inertia, [cm⁴], of profile (without plate flange)

$$= \frac{h_w t_w^{\ 3}}{3} 10^{-4} \text{ for flat bars (slabs)}$$

$$= \tfrac{1}{3}\left[h_w t_w^3 + b_f t_f^{\ 3}\left(1 - 0.63\frac{t_f}{b_f}\right)\right] 10^{-4}$$

- for flanged profiles

I_p =polar moment of inertia, [cm⁴], of profile about connection of stiffener to plate

$$= \frac{h_w^3 t_w}{3} 10^{-4} \text{ for flat bars (slabs)}$$

$$= \left(\frac{h_w^3 t_w}{3} + h_w^2 b_f t_f\right) 10^{-4} \text{ for flanged profiles}$$

I_W = sectorial moment of inertia, [cm⁶], of profile about connection of stiffener to plate

$$= \frac{h_w^3 t_w^3}{36} 10^{-6} \text{ for flat bars (slabs)}$$

$$= \frac{t_f b_f^{\ 3} h_w^2}{12} 10^{-6} \text{ for 'Tee' profiles}$$

$$= \frac{b_f^3 h_w^2 [t_f \left(b_f^2 + 2 b_f h_w + 4 h_w^2\right) + 3 t_w b_f h_w] 10^{-6}}{12 (b_f + h_w)^2}$$

- for angles and bulb profiles

C = spring stiffness exerted by supporting plate panel

$$= \frac{k_p E t_p^3 t_w^3}{\left(3 s t_w^3 + 4 k_p h_w t_p^3\right)}$$

$k_p = 1 - \eta_p$, not to be taken less than zero; and for flanged profiles need not be taken less than 0.1.

t_p = net plate thickness, [mm], after deduction of 't_c' as given in 2.1.1.

$$\eta_p = \frac{\sigma_c}{\sigma_{Ep}}$$

σ_c = calculated compressive stress for longitudinals as per Sec.6.3.

σ_{Ep} = elastic buckling stress of supporting plate calculated as per 6.2.1.

6.2.5 The σ_E value for the web buckling mode of longitudinals may be taken as :

$$\sigma_E = 3.8 E \left(\frac{t_w}{h_w}\right)^2 [\mathrm{N/mm^2}]$$

Buckling of flanges on angles and T-sections of longitudinals is taken care of if the as built flange thickness is not less than 1/15 of the flange width on one side of the web.

6.2.6 The σ_E value for axially loaded members may be taken as:

$\sigma_E = 0.001\ C\ E\ (i / l_m)^2$ [N/mm²]
C = 1.0 for both ends hinged
= 2.0 for one end fixed
= 4.0 for both ends fixed

Table 6.2.4				
	0 < K < 4	4 < K < 36	36 < K < 144	$(m-1)^2\ m^2 < K \le m^2\ (m+1)^2$
m	1	2	3	m

i = radius of gyration of the member, [cm]

$$= \sqrt{(I/a)}$$

I = moment of inertia of the member, [cm^4], about the axis perpendicular to the direction of buckling being considered

a = cross sectional area of the member, [cm^2]

l_m = length of the member, [m].

Where end connections of a member are different with respect to the two principal axes, σ_E is to be found out for both cases using appropriate values of 'C' and 'I'.

6.3 Compressive stress, σ_c

6.3.1 The σ_c value for plate panels and stiffeners taking part in the longitudinal strength is to be taken as :

$$\sigma_c = (M_s + M_w)\frac{z}{I_n}10^5\ [N/mm^2];$$

but not to be taken less than 30/k [N/mm^2]

where,

M_s = still water bending moment [kN-m] as per Pt.3, Ch.5

M_w = wave bending moment [kN-m] as per Pt.3, Ch.5

Values of sagging moments (M_s and M_w) are to be considered for members above the neutral axis and the hogging values for members below the neutral axis.

I_n = moment of inertia of the hull girder about the neutral axis, [cm^4]

z = vertical distance [m], from the neutral axis of the hull girder to the member under consideration.

For ships with high speed and large flare in the forebody, σ_c as obtained from above is to be increased by σ_{ca} in the region forward of 0.3L abaft of F.P. The value of σ_{ca} is to be taken as :

σ_{ca} = 0 for C_{af} < 0.4

$$= \frac{50}{k}\left(1 - \frac{x}{0.3L}\right)[N/mm^2]\,\text{for } C_{af} > 0.5$$

where,

x = distance [m], from F.P., however need not be taken as smaller than 0.1L

C_{af} = factor as defined in Pt.3, Ch.5, 2.2.2.

For intermediate values of C_{af}, σ_{ca} is to be obtained by interpolation.

6.3.2 The σ_c value for axially loaded members is to be taken as :

$$\sigma_c = \frac{10.F}{a}\ [N/mm^2]$$

where,

a = cross - sectional area of the member, [cm^2].

F = Nominal axial force in the member;

= A_L . p . 10^3 [kN]

A_L = Load area, [m^2], being supported by the member

In the calculation of axial force F for deck pillars, contributions, if any, from the decks above are also to be considered.

In the calculation of axial force F for cross ties or panting beams, the larger of the design pressure 'p' at the either ends of the member is to be considered.

End of Chapter

Chapter 4

Design Loads

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The scantlings of various hull members are to be based on the design values of ship motions, accelerations, lateral pressures and forces given in this Chapter.

The design values of pressure caused by slamming, bow impact and sloshing have been given in the relevant Chapters dealing with specific structures.

1.2 Symbols

1.2.1 L, B, T, V, C_b are as defined in Ch.1, Sec.2.

g_o = Standard acceleration due to gravity

= 9.81 [m/s^2]

ρ = density of liquid cargo or dry cargo, [t/m^3].

p = design pressure [N/mm^2]

C_w = 0.0856L for L $\leq$ 90 [m]

= 10.75 - [(300-L)/100]$^{3/2}$ for 90 < L< 300 [m]

= 10.75 for 300 $\leq$ L $\leq$ 350 [m]

= 10.75 - [(L-350)/150]$^{3/2}$ for L > 350 [m]

a_o = common acceleration parameter

$$= \frac{3C_w}{L} + \frac{C_v V}{\sqrt{L}}$$

where,

$$C_v = \frac{\sqrt{L}}{50} \text{ for } L < 100 [m]$$

= 0.2 for L $\geq$ 100 [m]

1.2.2 For ships with service limitations, the wave bending moments and shear forces and the dynamic components of external sea pressures are to be reduced by application of the reduction factor 'R_s' as given below:

R_s = 1.0 for unrestricted service
= 0.75 for coastal service
= 0.65 for restricted service
= 0.55 for sheltered water service.

For definitions of service limitations, see Pt.1 Ch.1.

Section 2

Ship Motions and Accelerations

2.1 Roll and pitch angles

2.1.1 The values of single amplitudes of roll and pitch angles (corresponding to their periods T_r and T_p respectively), are normally to be taken as:

- The roll angle, $\Phi = \frac{50\,c}{B+75}$ [radians]

where,

$c = (1.25 - 0.025\,T_r)\,d$

d = 1.2 for ships without bilge keel

= 1.0 for ships with bilge keel having area equal to 2.5% of LxB

For other percentages of bilge keel areas 'd' is to be interpolated.

T_r is not to be taken greater than 30 [s]

- the pitch angle, $\theta = 0.25\,\frac{a_o}{C_b}$ [radians]

2.2 Acceleration components

2.2.1 The design values of various acceleration components are normally to be taken as :

- the surge acceleration,

$a_x = 0.2\,g_o a_o\,\sqrt{C_b}$ [m/s^2]

- the combined sway/yaw acceleration

$a_y = 0.3\,g_o\,a_o$ [m/s^2]

- the heave acceleration

$$a_z = \frac{0.7 g_o a_o}{\sqrt{C_b}}\ [\mathrm{m/s^2}]$$

- the tangential roll acceleration, (excluding gravity)

$$a_r = \phi\left\{\frac{2\pi}{T_r}\right\}^2\ R_r\ [\mathrm{m/s^2}]$$

where,

ϕ = roll angle as given in 2.1.1

T_r = period of roll. [s].

= ($2k_r / \sqrt{GM}$)

k_r = roll radius of gyration, [m].

GM = metacentric height, [m].

Minimum value of T_r resulting from various possible combinations of k_r and GM is to be used.

In case detailed calculations for k_r and GM have not been carried out, the following values may be used.

k_r = 0.39B for ships with even transverse distribution of mass

= 0.35B for tanker in ballast

= 0.25B for ships loaded with ore between longitudinal bulkheads.

GM = 0.07B

R_r = distance from the centre of the mass under consideration to the axis of rotation, [m].

The axis of rotation for roll may be taken on the centre line of the ship and at a height 'z' above base line

where,

$$z = \left[\frac{D}{4} + \frac{T}{2}\right]\ [\mathrm{m}]\ \text{or,}$$

$$= \frac{D}{2}\ [\mathrm{m}]$$

whichever is smaller.

- the radial roll acceleration may normally be neglected.

The tangential pitch acceleration, (excluding gravity):

$$a_p = \theta \left[\frac{2\pi}{T_p} \right]^2 R_p \ [\mathrm{m/s^2}]$$

where,

θ = pitch angle as given in 2.1.1

$$T_p = 1.8\sqrt{(L/g_o)}\ [\mathrm{s}]$$

R_p = distance from the centre of the mass under consideration to the axis of rotation [m].The axis of rotation for pitch may be taken at 0.45L from A.P. and 'z' [m] above base line.

- the radial pitch acceleration may normally be neglected.

2.3 Combined accelerations

2.3.1 The combined accelerations in the ship's vertical, transverse, and longitudinal directions are to be taken as:

- the combined vertical acceleration (combined effect of heave, pitch and roll; excluding gravity)

$$a_V = \sqrt{\left(a_Z^2 + a_{rz}^2 + a_{pz}^2\right)}\ [\mathrm{m/s^2}]$$

where,

a_z = heave acceleration as given in 2.2.1

a_{rz} = vertical component of the tangential roll acceleration as given in 2.2.1

a_{pz} = vertical component of the tangential pitch acceleration as given in 2.2.1.

It may be noted that the components a_{rz} and a_{pz} may be obtained from the formulae given in 2.2.1 using the horizontal projections of the distances R_r and R_p as given below :

Horizontal projection of R_r = R_{rh} = Transverse distance between horizontal coordinate of the centre of mass under consideration to axis of rotation for roll

Horizontal projection of R_p = R_{ph} = Longitudinal distance between longitudinal coordinate of the centre of mass under consideration to axis of rotation for pitch (see Fig.2.3 (a))

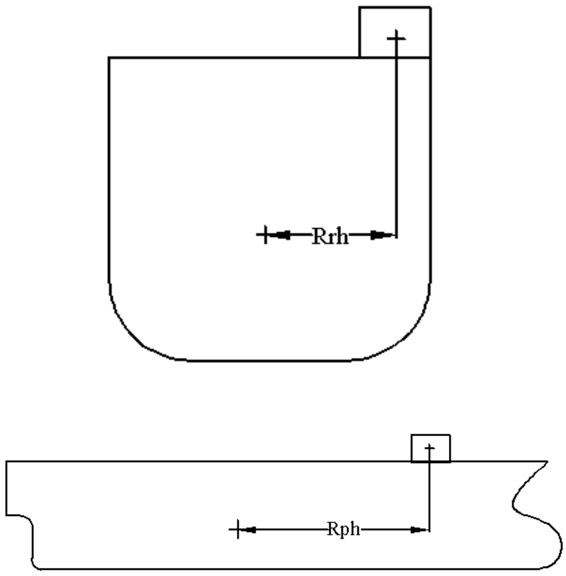


Fig.2.3 (a) : R_{rh} and R_{ph} Distances

- a_v may be approximated as

$$a_v = k_v \frac{g_o a_o}{C_b}\ [\mathrm{m/s^2}]$$

where,

k_v = 1.3 aft of A.P.

= 0.7 between 0.3L and 0.6L from A.P.

= 1.5 forward of F.P.

Between these specified regions k_v may be obtained by linear interpolation.

- the combined transverse acceleration, (combined effect of sway, yaw & roll)

$$a_t = \sqrt{\left[a_y^2 + \left(g_o \mathrm{Sin}\varphi + a_{ry}\right)^2\right]}\ [\mathrm{m/s^2}]$$

where,

a_y = sway/yaw acceleration as given in Sec.2.2.1

a_{ry} = transverse component of tangential roll acceleration given in Sec.2.2.1, the same may be obtained by using in the formula the vertical projection of the distance R_r as given below :

Vertical projection of R_r = R_{rv} = Vertical distance between vertical coordinate of the centre of mass under consideration to axis of rotation for roll (see Fig.2.3 (b))

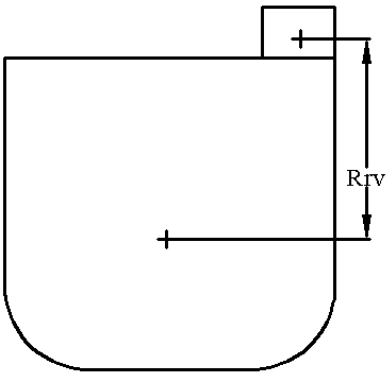


Fig.2.3 (b) : R_{rv} Distance

- the combined longitudinal acceleration, (combined effect of surge and pitch)

$$a_l = \sqrt{\left[a_x^2 + \left(g_o \mathrm{Sin}\theta + a_{px}\right)^2\right]}\ [\mathrm{m/s^2}]$$

where,

a_x = surge acceleration given in 2.2.1

a_{px} = longitudinal component of the tangential pitch acceleration given in 2.2.1, the same may be obtained by using in the formula the vertical projection of the distance R_p as given below :

Vertical projection of R_p =R_{pv}= vertical distance between vertical coordinate of the centre of mass under consideration to axis of rotation for pitch (see Fig.2.3 (c))

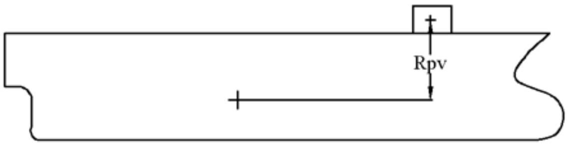


Fig.2.3 (c) : R_{pv} Distance

Section 3

Design Pressures and Forces

3.1 General

3.1.1 The scantlings of shell and weather deck panels are to be based upon the external sea pressures given in Sec.3.2, or internal pressure, in way of tanks as given in Sec.3.3 if these be greater. While determining internal pressures on shell panels, external sea pressure at ballast draught given in 3.2.4 may be deducted.

Inner bottoms, decks and hatch covers supporting dry cargo, stores and accommodation spaces are to be based upon design pressures given in Sec.3.4.

The gravity and acceleration forces from heavy units of cargo and equipment which may influence scantlings are given in Sec.3.5.

3.1.2 The design pressures are to be calculated at the loadpoint which is defined for various strength members as follows.

Loadpoint for plates

- midpoint of horizontally stiffened plate field

- half the stiffener spacing above the lower support of vertically stiffened plate field, or at the lower edge of plate when the thickness is changed within the plate field.

Loadpoint for stiffeners

- midpoint of span.

(when the pressure variation over the length of the span is not linear, the design pressure to be used is to be taken as the greater of p_m and $1/2(p_a+p_b)$ where, p_m = calculated pressure at midpoint
p_a, p_b = calculated pressures at two ends of the span)

Loadpoint for girders

- midpoint of load area supported by the girder

3.2 External sea pressures

3.2.1 All decks or parts of decks, which are exposed to the wash of sea are to be treated as weather decks.

3.2.2 The pressure 'p' acting on the ships' side, bottom and weather decks is to be taken as:

- for load point below summer load waterline

$$\rho = 0.01\,h_o + \left(k_s - \frac{1.5h_o}{T}\right)C_w . R_s .10^{-3}\ [\mathrm{N/mm^2}]$$

- for load point above summer load waterline

$p = R_s \,.\, k_s\,(C_w - 0.8\,h_o)\,.\,10^{-3}$ [N/mm^2]

where,

h_o = vertical distance [m] ,from the summer load waterline to the loadpoint.

k_s = 6 aft of A.P.

= 3.5 between 0.2L and 0.7L from A.P.

= 8/C_b forward of F.P.

Elsewhere the value of k_s may be obtained by linear interpolation.

'p' is not to be taken as less than:

0.01 [N/mm^2] for ship sides

0.015 [N/mm^2] for weather decks forward of 0.15L from F.P. or forward of deckhouse front, whichever is the foremost position.

0.005 [N/mm^2] for weather decks elsewhere.

3.2.3 The design pressure 'p' on inner bottom (double bottom flooded) is to be taken as

p = 0.01 T [N/mm^2]

3.2.4 The external sea pressure 'p' at ballast draught which may be deducted from internal pressures acting on shell panels as given in 3.3 is not to be taken greater than:

$p = 0.01\,(T_b - z) + (k_s - 1.5)\,C_w \,.\, R_s\,.10^{-3}$ [N/mm^2]

- for open sea conditions;

$p = 0.01(T_b - z)$ [N/mm^2]

- for harbour conditions.

p is not to be taken as less than zero.

where,

T_b = lowest design ballast draught amidships [m]. For preliminary purposes T_b may be taken as 0.35 T for cargo vessels and (2 + 0.02L) for tankers.

z = vertical distance [m] from the baseline to the loadpoint.

3.3 Internal pressures on tank structures

3.3.1 In case of tanks for crude oil or bunkers the liquid cargo density 'ρ is not to be taken less than that of sea water (ρ=1.025 [t/m^3]).

3.3.2 The pressure 'p', [N/mm^2] , in full tanks is to be taken as the greater of:

$p = \rho\,(g_o+0.5a_v)h_s\,.\,10^{-3}$ (1)

$p = 0.67\,\rho\,g_o(h_s+\phi b)\,.10^{-3}$ (2)

$p = 0.67\,\rho\,g_o(h_s+\theta l)\,.10^{-3}$ (3)

$p = 0.67\,\rho\,g_o\,h_p\,.\,10^{-3}$ (4)

$p = \rho\,g_o\,h_s\,.\,10^{-3} + p_o$ (5)

where,

a_v = combined vertical acceleration as given in 2.3.1

ϕ = roll angle as given in 2.1.1

θ = pitch angle as given in 2.1.1

h_s = vertical distance [m], from the load point to the top of cargo hatchway

b = the largest athwartship distance [m] ,from the load point to the tank corner at the top of the tank which is furthermost away from the load point. For tank tops with stepped contour, the uppermost tank corner will normally be decisive.

l = the largest longitudinal distance [m] ,from the load point to the tank corner at the top of the tank which is furthermost away from the load point. For tank tops with stepped contour, the uppermost tank corner will normally be decisive.

h_p = vertical distance [m], from the load point to the top of the air pipe.

p_o = 0.01 [N/mm^2] for L ≤ 20 [m]

$= 0.024$ [N/mm^2] for $L \geq 90$ [m]

For L between 20 [m] and 90 [m] the value of 'p_o' is to be obtained by linear interpolation.

However, in mechanically propelled cargo ships of 500 GT and above and passenger ships, for tanks forming part of the watertight subdivision, (See Ch.10, Cl.4.2.1) p_0 is to be taken as not less than 0.024 [N/mm^2].

Where automatic pressure valves are fitted, p_o is not to be taken as less than valve setting pressure.

The formulae which normally give the greatest internal pressure p are indicated in Fig.3.3.2a, Fig.3.3.2b and Fig.3.3.2c for various tank types.

The external sea pressure at ballast draught for open sea conditions as per 3.2.4 may be deducted from that given by formulae (1),(2) and (3) above.

The external sea pressure at ballast draught for harbour conditions as per 3.2.4 may be deducted from that given by formulae (4) and (5) above.

3.3.3 The pressure 'p' in tanks which may be filled between 20 per cent and 90 per cent of the tank heights is to be taken as the greater of that according to 3.3.2 and the relevant values given below:

- for strength members located within 0.25 l_t from the end bulkheads 'p' is not to be taken as less than:

$p = \rho\ [4 - 0.005L]\ l_t\ 10^{-3}$ [N/mm^2]

where,

l_t = distance [m], between transverse tank bulkheads or effective transverse wash bulkheads at the height at which the strength member is located. Transverse webframes covering part of the tank cross-section (e.g. wing tank structures in tankers) may be regarded as wash bulkheads for this purpose.

for strength members located within 0.25 b_t from the tank side bulkheads the pressure 'p' is not to be taken as less than:

$p = \rho\ [3 - 0.01B]\ b_t\ 10^{-3}$ [N/mm^2]

where,

b_t = distance [m], between tank side bulkheads or effective wash bulkhead at the height at which the strength member is located.

- for tanks with $l_t > 0.13L$ and/or $b_t > 0.56B$, p will be specially considered.

3.3.4 The pressure 'p' acting on girder web panels in cargo tanks or ballast tanks is not to be taken as less than 0.02 [N/mm^2].

3.4 Pressures due to dry cargoes, stores, equipment and accommodation

3.4.1 The pressure 'p' on inner bottom, decks or hatchcovers is to be taken as:

$p = q(g_o + 0.5\ a_v) \times 10^{-3}$ [N/mm^2]

where,

q = deck cargo load [t/m^2].

The standard values of `q' are given in Table 3.4.1. Where approval is sought for loadings higher than the standard loading, the same is to be indicated on the plans.

3.4.2 Weather deck and weather deck hatch covers intended to carry deck cargo are to be designed for external sea pressure as given in 3.2.2 or pressure due to deck cargo as given in 3.4.1, whichever is greater.

When the design stowage height of weather deck cargo is smaller than 2.3 [m], an appropriate combination of the two loads is to be considered.

3.4.3 The pressure 'p' from bulk cargoes on sloping and vertical sides or bulkheads is to be taken as:

$$p = C.\rho.h_c(g_o + 0.5\ a_v)\ .\ 10^{-3}\ \text{[N/mm}^2\text{]}$$

where,

$C = \sin^2\alpha\ \tan^2(45 - \delta/2) + \cos^2\alpha$

α = angle made by the panel under consideration with the horizontal plane, [degree]

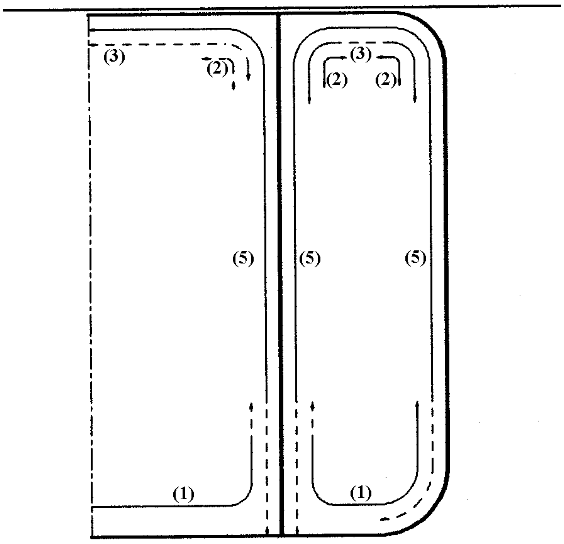


Fig. 3.3.2 (a) : Section in cargo tanks

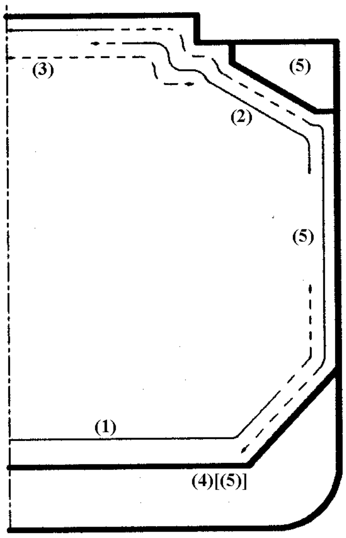


Fig. 3.3.2 (b) : Section in bulk cargo hold

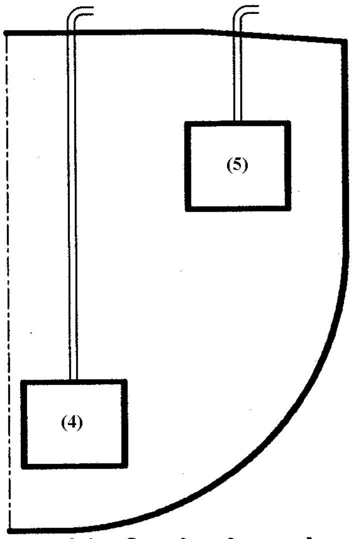


Fig. 3.3.2 (c) : Section in engine room

Table 3.4.1 : Standard deck loads

Decks	q[tonnes/m^2]
Weather deck and weather deck hatch covers intended for cargo	$q = 1.0$ t/m^2 for $L \leq 100$ m $= 1.3$ t/m^2 on superstructure deck for $L > 150$ m $= 1.75$ t/m^2 on freeboard deck for $L > 150$ m For L between 100 m and 150 m the standard value of q is to be obtained by linear interpolation
Tween deck, tween deck hatch covers and inner bottom in way of cargo and stores	$q = \rho.H.t/m^2$ $\rho = 0.7$ t/m^3 (see note) where, H = tween deck height in m or height measured upto the top of hatchway coaming above
Platform deck in machinery space	$q = 1.6$ t/m^2
Accommodation decks	$q = 0.35$ t/m^2
Note In case of ships where due to large volumetric capacity of cargo spaces the stowage rate is less than 0.7 [t/m^3], a reduction in the value of 'ρ' may be considered, if requested for.	

δ = angle of repose of cargo [degree], not to be taken greater than the following:
- 20° for light bulk cargo (e.g. coal, grain)
- 25° for bulk cement cargo
- 35° for heavy bulk cargo (e.g. ore)

h_c = vertical distance [m], from the load point to the mean horizontal plane corresponding to actual volume of cargo being considered.

For vessels designed to carry heavy bulk cargoes which are also required to carry lighter cargoes, the pressure 'p' based on maximum mass of cargo to be carried in the hold and filled up to the top of hatch coaming would also require to be considered.

3.5 Forces due to heavy units of cargo and equipment

3.5.1 The forces acting on supporting structures and securing systems for heavy units of cargo, equipment etc. are normally to be taken as:

- vertical force, alone:

$F_v = M (g_o + 0.5a_v)$ [N]

- vertical force in combination with transverse force:

$F_v = M.g_o$ [N]

$F_t = 0.67\ M.a_t$ [N]

- vertical force in combination with longitudinal force:

$F_v = M(g_o + 0.5a_v)$ [N]

$F_l = 0.67\ M.a_l$ [N]

where,

M = mass of the unit [kg].

F_v, F_t, F_l = forces acting in the vertical, transverse
and longitudinal directions respectively.

F_t and F_l need not be regarded as acting simultaneously.

a_v, a_t, a_l = combined accelerations in the vertical, transverse and longitudinal directions respectively, as given in 2.3.1.

End of Chapter

Chapter 5

Longitudinal Strength

Contents

Section

Section 1

General

1.1 Application

1.1.1 Scantlings of hull members contributing to longitudinal strength are to comply with the requirements given in this Chapter. These members are also to comply with the requirements of buckling strength given in Ch.3, Sec.6 and of local strength given in relevant chapters of Pt.3.

1.1.2 For ships with small block coefficient, high speed and large flare (in particular where L>120 [m] and speed V>17 knots), the section modulus in the forebody is to be specially considered based on the distribution of still water and vertical wave bending moments given in Sec.2.1 and Sec.2.2 respectively.

1.1.3 For ships with narrow beams the combined effects of vertical and horizontal bending of hull girder may have to be specially considered as given in 3.3.4.

1.1.4 For ships with large deck openings the combined effects of hull girder bending and torsion related possible local bending and shear stresses may have to be specially considered.

1.1.5 In addition to the above, ships of unusual type, design or proportions ($L/B \le 5$, $B/D \ge 2.5$, $L \ge 500$ [m]), will be specially considered.

1.1.6 Longitudinal strength requirements given in this section do not apply to Container Ships. Requirements given in Pt 5 Ch 5 Sec 4 are applicable to container ships.

1.2 Symbols

L, B, D, T, V, C_b, k as defined in Ch.1, Sec.2.

C_w, R_s as defined in Ch.4, Sec.1.

I_n = moment of inertia of hull girder, [cm^4], about the transverse neutral axis at the section under consideration.

I_c = moment of inertia of hull girders, [cm^4], about the vertical neutral axis at the section under consideration.

S_n = first moment of area, [cm^3], taken about the neutral axis, of the effective longitudinal material between the vertical level at which the shear is being determined and the vertical extremity of effective longitudinal material (deck or bottom as applicable), at the section under consideration.

Z_n = vertical distance [m] of the horizontal neutral axis above base line.

M_s = design still water bending moment [kN-m] as given in 2.1.2 and 2.1.3.

M_w = rule wave bending moment [kN-m] as given in 2.2.1 and 2.2.2.

Q_s = design still water shear force [kN] as given in 2.1.4.

Q_w = rule wave shear force [kN] as given in 2.2.3.

1.3 Terms

1.3.1 Effective longitudinal bulkhead :

A longitudinal bulkhead extending from bottom to deck and which is connected to the ship's side by transverse bulkheads both forward and aft.

Loading Manual:

A document which describes:-

- the loading conditions on which the design of the ship has been based, including permissible limits of still water bending moment and shear force
- the results of the calculations of still water bending moments, shear forces and where applicable, limitations due to torsional and lateral loads
- the allowable local loadings for the structure (hatch covers, decks, double bottom, etc.)

An operation manual is always to be provided with the loading instrument.

Loading Instrument:

An instrument, which unless otherwise stated is digital, by means of which it can be easily and quickly ascertained that, at specified read-out points, the still water bending moments, shear forces, and the still water torsional and lateral loads, where applicable, in any loaded or ballast condition will not exceed the specified permissible values.

Category I Ships :

Ships with large deck openings where combined stresses due to vertical and horizontal hull girder bending, torsional and lateral loads have to be considered; e.g. container ships.

Ships liable to carry non-homogeneous loadings, where the cargo and/or ballast may be unevenly distributed; e.g. bulk carriers, tankers. Ships less than 120 [m] in length, when their design takes into account uneven distribution of cargo or ballast, belong to Category II.

Chemical tankers and gas carriers.

Category II Ships :

Ships with arrangement giving small possibilities for variation in the distribution of cargo and ballast, and ships on regular and fixed trading pattern where the Loading Manual gives sufficient guidance, and in addition those exceptions given under Category I.

Section 2

Vertical Bending Moments and Shear Forces

2.1 Still water bending moment and shear force

2.1.1 Still water bending moments, M_s [kN-m], and still water shear forces, Q_s [kN], are to be calculated at each section along the ship length for design cargo and ballast loading conditions as specified in 2.1.2. For these calculations, downward loads are assumed to be taken as positive values, and are to be integrated in the forward direction from the aft end of L. The sign conventions of Ms and Qs are as shown in Fig.2.1.1.

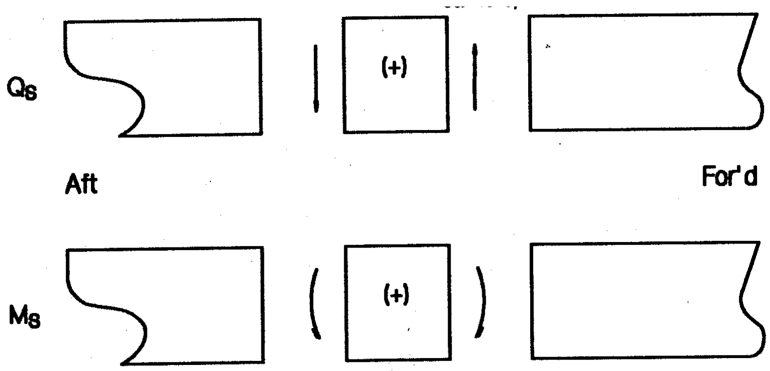


Fig. 2.1.1 : Sign conventions of M_s and Q_s

2.1.2 In general the following conditions (based on the amounts of bunker, fresh water, stores etc. at departure and arrival), are to be considered for the calculations of M_s and Q_s. Where the amount and disposition of consumables at any intermediate stage of the voyage are considered more severe, calculations for such intermediate conditions are to be submitted in addition to those for departure and arrival conditions. Also, where any ballasting and/or deballasting is intended during voyage, calculations of the intermediate condition just before and just after ballasting and/or deballasting any ballast tank are to be submitted and where approved, included in the loading manual for guidance.

a) General cargo ships, container ships, roll-on/roll-off and refrigerated cargo carriers, bulk carriers, ore carriers:

- Homogeneous loading conditions at maximum draught
- Ballast conditions
- Special loading conditions e.g. container or light load conditions at less than maximum draught, heavy cargo, empty holds or non-homogeneous cargo conditions, deck cargo conditions etc., where applicable
- Short voyage or harbour conditions, where applicable
- Docking condition afloat
- Loading and unloading transitory conditions, where applicable.

b) Oil tankers:

- Homogeneous loading conditions (excluding dry and clean ballast tanks) and ballast or part loaded conditions.
- Any specified non-uniform distribution of loading.
- Mid-voyage conditions relating to tank cleaning or other operations where these differ significantly from the ballast conditions.
- Docking condition afloat
- Loading and unloading transitory conditions.

c) Chemical tankers:

- Conditions as specified for oil tankers.
- Conditions for high density or heated cargo and segregated cargo, where these are included in the approved cargo list.

d) Liquefied gas carriers:

- Homogeneous loading conditions for all approved cargoes.
- Ballast conditions.
- Cargo conditions where one or more tanks are empty or partially filled or where more than one type of cargo having significantly different densities are carried.
- Harbour condition for which an increased vapour pressure has been approved.
- Docking condition afloat.

e) Combination carriers:

- Conditions as specified for oil tanker and cargo ships.

In addition to the above, any other loading condition likely to result in high bending moments or shear forces may require to be investigated.

For permissible use of partially filled ballast tanks in design loading conditions, See 2.1.3 and 2.1.4.

2.1.3 Ballast loading conditions involving partially filled peaks and/or other ballast tanks at departure, arrival or during intermediate conditions are not to be used as design conditions unless:

- permissible bending and shear stresses are not exceeded for all filling levels between empty and full; and
- for bulk carriers, the requirement for longitudinal strength of hull girder in flooded conditions as per Pt.5, Ch.1, Sec.2.2 are complied with for all filling levels between empty and full.

To demonstrate compliance with all filling levels between empty and full, it will be acceptable if, in each condition at departure, arrival and where required by 2.1.2 any intermediate condition, the tanks intended to be partially filled are assumed to be:

- empty
- full
- partially filled at intended level.

Where multiple tanks are intended to be partially filled, all combinations of empty, full or partially filled at intended level for those tanks are to be investigated.

The maximum and minimum filling levels of the above mentioned pairs of wing water ballast tanks are to be indicated in the loading manual.

2.1.4 In cargo loading conditions involving partially filled ballast tanks, the requirements given in 2.1.3 above need be applied in respect of peak tanks only.

2.1.5 Sequential ballast water exchange : Requirements of 2.1.3 and 2.1.4 above are not applicable to ballast water exchange using the sequential method. However, bending moment and shear force calculations for each de-ballasting or ballasting stage in the ballast water exchange sequence are to be included in the loading manual or ballast water management plan of any vessel that intends to employ the sequential ballast water exchange method.

However, for conventional ore carriers with large wing water ballast tanks in the cargo area, where empty or full ballast water filling levels of one or maximum two pairs of these tanks lead to the ship's trim exceeding one of the following conditions, it is sufficient to demonstrate compliance with maximum, minimum and intended partial filling levels of these one or maximum two pairs of ballast tanks such that the ship's condition does not exceed any of these trim limits. Filling levels of all other wing ballast tanks are to be considered between empty and full. The trim conditions mentioned above are:

- trim by stern of 3% of the ship's length, or
- trim by bow of 1.5% of ship's length, or
- any trim that cannot maintain propeller immersion (I/D) not less than 25%, where:
  - I = the distance from propeller centerline to the waterline
  - D = propeller diameter
  - (see Fig. 2.1.3).

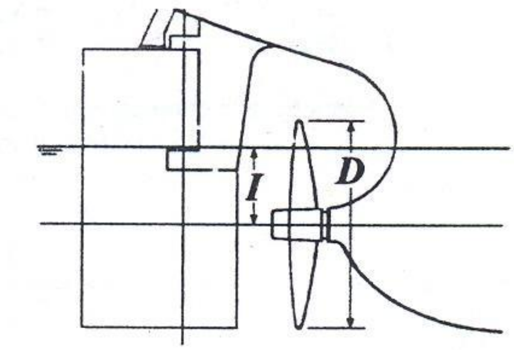


Fig.2.1.3

2.1.6 The design still water bending moment at amidships M_{so} (sagging and hogging), is to be taken equal to the maximum of sagging or hogging still water bending moments obtained for the loading conditions specified in Sec.2.1.2.

At locations other than amidships, 0.4L, the design still water bending moment Ms (sagging and hogging) is normally to be taken as:

$$M_s = K_{sm}.M_{so} \text{ [kN-m]}$$

where,

K_{sm} = 0.0 at A.P. and F.P.
= 0.15 at 0.1L from A.P. and F.P.
= 1.0 within 0.4L amidships.

Between the specified locations the value of K_{sm} is to be obtained by linear interpolation.

The longitudinal extent of the constant design still water bending moment amidships may be adjusted after special consideration based on the sagging and hogging moment envelopes embracing all the still water bending moment curves derived for loading conditions as specified in 2.1.2.

2.1.7 The design vertical still water shear force, Q_s, across any transverse section along the length of the ship is to be taken as the maximum of shear forces obtained at that location for the loading conditions specified in Sec.2.1.2.

2.2 Wave bending moment and shear force

2.2.1 The rule vertical wave bending moment M_{wo}, amidships is to be taken as

$M_{wo} = -0.11\ C_w L^2\ B(C_b + 0.7)\ R_s$ [kN-m]

- for sagging condition

$= +0.19\ C_w L^2\ B\ C_b R_s$ [kN-m]

- for hogging condition

C_b is not to be taken as less than 0.6

2.2.2 At locations other than amidships, the rule wave bending moment M_w (sagging and hogging) is to be taken as:

$M_w = K_{wm}.M_{wo}$

K_{wm} = 1.0 between 0.40L and 0.65L from A.P.

= 0.0 at A.P. and F.P.

Between the specified locations, K_{wm} is to be obtained by linear interpolation. This is indicated by curve 'A' of Fig.2.2.2.

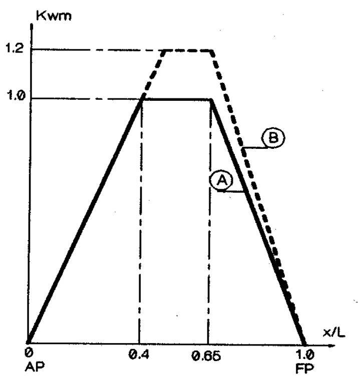


Fig. 2.2.2 : K_{wm} Distribution

However, for ships with high speed and/or large flare in the forebody, the value of K_{wm} is to be modified as per Table 2.2.2 using curves 'A' and 'B' of Fig.2.2.2 based on C_{av} and C_{af} given below:

$$C_{av} = \frac{C_v \cdot V}{\sqrt{L}}$$

$$C_{af} = C_v \frac{V}{\sqrt{L}} + \frac{A_{dk} - A_{wp}}{L\, z_{fp}}$$

$$C_v = \frac{\sqrt{L}}{50} \text{ for } L < 100$$

= 0.2 for $L \geq 100$

A_{dk} = projected area in horizontal plane of uppermost deck (including forecastle deck if any), forward of 0.2L from F.P., [m^2]

A_{wp} = area of waterplane at draught T, forward of 0.2L abaft of F.P. [m^2]

z_{fp} = vertical distance, [m], measured at F.P., from summer load water line to the deckline.

Table 2.2.2 : Modification to K_{wm} and K_{wq} values for high speed/flare

K_{wm}, K_{wq} values to be used as per the curve specified below:				
	$C_{av} \leq 0.28$		$C_{av} \geq 0.32$	
	Load condition	Curve	Load condition	Curve
$C_{af} \leq 0.4$	Hogging	A	Hogging	B
	Sagging	A	Sagging	A
$C_{af} \geq 0.5$	Hogging	A	Hogging	A
	Sagging	B	Sagging	B

For intermediate values of C_{av} and/or C_{af}, values of K_{wm}, K_{wq} are to be obtained by linear interpolation between specified curves

2.2.3 The rule vertical wave shear force Q_w at any section along the length of the ship is to be taken as:

$Q_w = 0.3\ K_{wq}\ C_w\ LB\ (C_b+0.7)\ R_s$ [kN] where, the distribution of K_{wq} for +ve and -ve shear forces, is to be obtained as per Table 2.2.3:

Between the specified locations K_{wq} is to be obtained by linear interpolation. This is indicated by curve 'A' of Fig.2.2.3.

However, for ships with high speed and/or large flare in the forebody, the value of k_{wq} is to be modified as per Table 2.2.2 using curves 'A' and 'B' of Fig.2.2.3 based on C_{av} and C_{af}.

Table 2.2.3

Location from A.P.	Positive Shear Force K_{wq} (+)	Negative Shear Force K_{wq} (-)
A.P.	0.0	0.0
0.2L to 0.3L	$\frac{1.589\,C_b}{(C_b+0.7)}$	-0.92
0.4L to 0.6L	0.70	-0.70
0.7L to 0.85L	1.0	$\frac{-1.727\,C_b}{(C_b+0.7)}$
F.P.	0.0	0.0

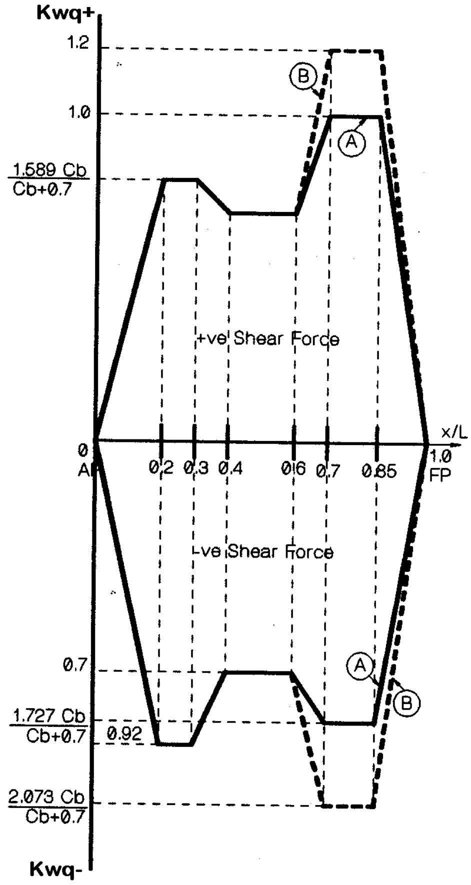


Fig. 2.2.3 : K_{wq} Variation

Section 3

Hull Section Modulus and Moment of Inertia

3.1 Calculation of section properties

3.1.1 When calculating the moment of inertia and section moduli, the effective sectional area (net area after deduction for openings as given in 5.2) of all continuous longitudinal strength members is to be taken into account.

Superstructures not forming strength deck (See Ch.1, Sec.2.2), deckhouses, bulwarks and non-continuous longitudinal hatch coamings are not to be included in the above calculations.

In case of ships with multi-hatchways athwartships, the effective sectional area of strength members between the hatch openings is normally to be taken as 0.6 times the net area of the members.

In case of ships with continuous trunks or longitudinal hatch coamings, their net sectional area may be included in the calculations provided they are effectively supported by longitudinal bulkheads or deep girders. The section modulus at deck however, is then to be calculated as given in 3.1.3.

3.1.2 The main strength members included in the calculation of hull moment of inertia and section modulus are to extend continuously through the cargo region and sufficiently far towards the ends of the ship. Longitudinal bulkheads are to terminate at effective transverse bulkheads and large transition brackets are to be fitted in line with the longitudinal bulkheads. Where significant changes in structural arrangement occur adequate transitional structure is to be provided.

3.1.3 The midship section modulus 'Z' at deck or bottom about the transverse neutral axis is to be obtained as follows:

$$Z = I_n / (100.z) \ \ [cm^3]$$

where,

z = the vertical distance [m] from the horizontal neutral axis upto the strength deck at side or the base line, as relevant.

However, in case of ships where continuous trunks or longitudinal hatch coamings are to be included in the section modulus calculation as per Sec.3.1.1, the distance z for calculation of modulus at deck is to be taken as the greater of the following:

z = z as above
$z = z_n$ [0.9 + 0.2 y/B]

where,

z_n = the vertical distance from the horizontal neutral axis to top of continuous strength member.

y = athwartship distance from the centreline of the ship to the side of the strength member.

z_n and y are to be measured to the point giving the largest value of z.

3.2 Extent of high strength steel

3.2.1 Where high strength steels are used in the main hull structure in order to reduce the section modulus requirement, the vertical and longitudinal extent of its use is to be such that adjacent structure made of ordinary hull structural steel is not stressed beyond the stress level permissible for ordinary steel.

3.2.2 The vertical extent of the high strength steel used in deck or bottom structure is to be as shown in the Fig.3.2.2, the distance z_o is not to be more than

$$z_o = I_n / (100.Z_{Ro}) \ \ [m]$$

where,

Z_{Ro} = Rule midship section modulus required for ordinary steel (k=1.0) as given in 3.3.1 and 3.3.2.

For narrow beam ships the vertical extent of high strength steel may have to be increased after special consideration.

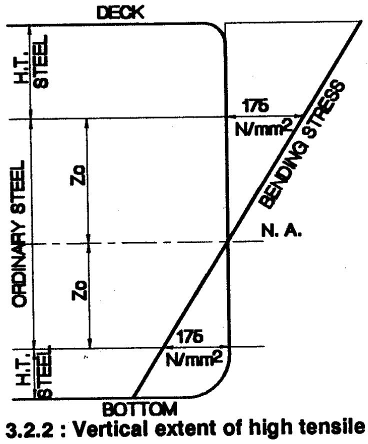


Fig. 3.2.2 : Vertical extent of high tensile steel

3.2.3 The longitudinal extent of the high strength steel is to be 0.4L amidships and beyond, such that at the junction with ordinary steel the scantlings are equal to those required for an identical ship built of ordinary steel. At the junction, continuity in scantlings is to be maintained.

3.3 Section modulus requirement

3.3.1 At any transverse section, the hull section modulus Z, about the transverse neutral axis for the still water bending moments Ms given in 2.1 and wave bending moments Mw given in 2.2, is not to be less than:

$$Z = \left(\frac{M_s + M_w}{\sigma_L} \right) \text{ x } 10^3 \ [\text{cm}^3]$$

where,

σ_L = permissible bending stress

= 175/k [N/mm^2] within 0.4L amidships

= 125/k [N/mm^2] within 0.1L from A.P. and F.P.

Between the specified regions σ_L is to be obtained by linear interpolation.

3.3.2 The minimum requirement of hull section modulus Z about the transverse neutral axis, at midship, is given by:

$$Z = k\ C_1\ L^2\ B\ (C_b+0.7)\ (0.5 + R_s/2)\ [\text{cm}^3]$$

where,

$C_1 = 4 + 0.0412\ L$ for L < 90 [m]

$C_1 = 10.75 - [(300-L)/100]^{3/2}$ for 90 [m] ≤ L < 300 [m]

= 10.75 for 300 [m] ≤ L ≤ 350 [m]

= $10.75 - [(L-350)/150]^{3/2}$ for L > 350 [m]

C_b is not to be taken as less than 0.6.

3.3.3 Scantlings of all continuous longitudinal members of hull girder based on the section modulus requirement 3.3.1 are to be maintained within 0.4L amidships.

However, in special cases, based on consideration of type of ship, hull form and loading conditions, the scantlings may be gradually reduced towards the ends of the 0.4L amidships part, bearing in mind the desire not to inhibit the vessel's loading flexibility.

In the region outside 0.4L amidships, the scantlings are to be gradually tapered to the local requirements at ends.

3.3.4 For ships mentioned in 1.1.3, the hull section modulus Z_h about vertical neutral axis, at midship, is to be such that the combined stress σ_{vh} as given below at deck and bilge corners does not exceed 195/k [N/mm^2].

$$\sigma_{vh} = \sigma_s + \sqrt{(\sigma_w^2+\sigma_{wh}^2)}$$

where,

σ_s = stress due to M_s

σ_w = stress due to M_w

σ_{wh} = stress due to horizontal wave bending moment M_{wh} given by

$Mwh = 0.44L^{2.25}\ (T + 0.3\ B)\ C_b\ R_s$ [kN-m]
- at midship;

= 0 at ends;

For intermediate locations the value of M_{wh} is to be obtained by linear interpolation.

The above requirement is normally satisfied when Z_h is not less than

$$Z_h = 5\ k\ L^{2.25}\ (T + 0.3\ B)\ C_b\ R_s\ [\text{cm}^3]$$

3.4 Moment of inertia requirement

3.4.1 The moment of inertia In of the hull section about the transverse neutral axis, at midship, is not to be less than:

$$I_n = 3\ C_1\ L^3\ B\ (C_b+0.7)\ R_s\ [\text{cm}^4].$$

3.5 Bending strength outside amidships

The required bending strength outside 0.4L amidships is to be determined as specified in 3.3.1

As a minimum, hull girder bending strength checks are to be carried out specifically at the following locations:

- In way of the forward end of the engine room.
- In way of the forward end of the foremost cargo hold.
- At any locations where there are significant changes in hull cross-section.
- At any locations where there are changes in the framing system.

Buckling strength of members contributing to the longitudinal strength and subjected to compressive and shear stresses is to be checked, in particular in regions where changes in the framing system or significant changes in the hull cross-section occur. The buckling evaluation criteria is given in Ch.3, Sec.6.

For ships with large deck openings such as containerships, sections at or near to the aft and forward quarter length positions are to be checked. For such ships with cargo holds aft of the superstructure, deckhouse or engine room, strength checks of sections in way of the aft end of the aft-most holds and the aft end of the deckhouse or engine room are to be performed.

Section 4

Shear Strength

4.1 General

4.1.1 The shear stress 'τ' in ship's sides and longitudinal bulkheads based on the total shear force (Q_s+Q_w) is not to exceed 110/k [N/mm^2].

4.2 Side shell and longitudinal bulkheads thickness requirement

4.2.1 The thickness of the side shell (or combined thickness of the inner and outer shell in case of double skin construction) and longitudinal bulkheads, where fitted, is not to be less than that given by:

$$t = \frac{|\phi(Q_s + Q_w) + \Delta Q_s|}{\tau}(S_n/I_n).10^2 \text{ [mm]}$$

where,

ϕ = shear force distribution factor

= 0.5 for ships without effective longitudinal bulkheads

= as given in Table 4.2.1, for the item under consideration, for ships with effective longitudinal bulkheads

ΔQ_s = shear correction due to uneven load distribution and shear carrying longitudinal bottom members and may be taken as:

ΔQ_s = 0 for nearly uniform loading conditions

- For bulk carriers of conventional design:

$$\Delta Q_s = \frac{B.l_h.B_h.P_c}{2.2(B + l_h)} \text{ [kN]}$$

where,

l_h = length of the hold [m]

B_h = breadth of the flat part of the double bottom [m]

P_c = net downward loading on the flat part of the double bottom [kN/m^2] as given below.

- For ships with effective longitudinal bulkheads

$$\Delta Q_s = n\,(l_b \,.\, F_t - l_e \,.\, F_p) \text{ [kN]}$$

where,

F_t, F_p = as given in Table 4.2.1 for the item under consideration, [kN/m]

l_b = length between tank bulkheads [m]

Transverse wash bulkheads with openings more than 20% are to be considered ineffective for the purpose of determining lb.

l_e = l_b - S

S = spacing of bottom transverses, [m]

n = 0.5 at aft end of l_b

= –0.5 at fore end of l_b

A_S = sectional area of the side shell plating (or combined area of the inner and outer shell plating), [cm^2].

A_L, A_C = Sectional area of the longitudinal wing bulkhead plating and centre line bulkhead plating respectively, [cm^2]. In case of corrugated bulkheads the area is to be taken as the product of mean thickness and the depth.

c, w, d = breadths of the centre tank (or flat portion of hold between hopper tanks), wing tank and double side tank respectively, [m].

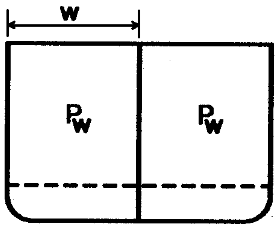
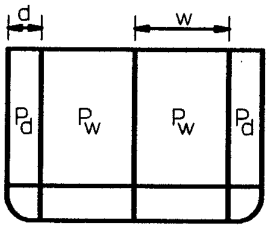
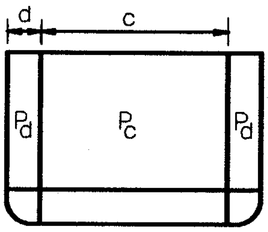
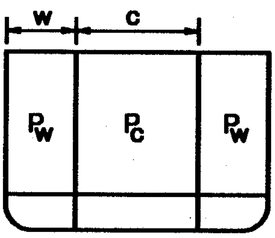
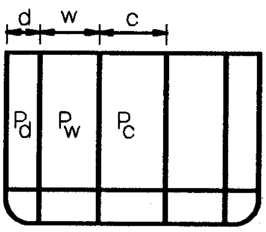
P_c, P_w, P_d = net (downward +ve) static loading [kN/m^2] on bottom in centre tank (or flat portion of hold between hopper tanks), wing tank and double side tank respectively.

The net loading is to be arrived at considering the downward loading of solid or liquid cargo above inner bottom together with that of ballast, if any, in double bottom tanks below and the upward buoyancy loading corresponding to the draught at midpoint of the part concerned in the loading condition under consideration.

β = 0.7 where a substantially deep girder has been provided on centre line of the ship.

= 1.0 in other cases.

Table 4.2.1 : Shear force distribution factors (ϕ_S, ϕ_L, ϕ_C) and correction factors (F_t, F_p) for ships with effective longitudinal bulkheads

Cross Section	Item	ϕ	F_t	F_p
	Side shell	$\phi_S = 0.5\,(1 - \phi_C)$	$2\,P_w \cdot w$	$0.5\,P_w \cdot w$
	C.L. Bhd.	$\phi_C = \dfrac{1.15A_C}{2A_S + A_C}$		$P_w \cdot w$
	Double skin	$\phi_S = 0.5\,(1 - \phi_C)$	$2\,(P_d \cdot d + P_w \cdot w)$	$P_d \cdot d + 0.5\,P_w \cdot w$
	C.L. Bhd.	$\phi_C = \dfrac{1.35A_C}{2A_S + A_C}$		$P_w \cdot w$
	Double skin	$\phi_S = 0.5$	$2\,P_d \cdot d + P_c \cdot c$	$P_d \cdot d + 0.5\,\beta \cdot P_c \cdot c$
	Side shell	$\phi_S = 0.5 - \phi_L$	$2\,P_w + P_c \cdot c$	$0.5\,P_w \cdot w$
	longl. bhd.	$\phi_L = \dfrac{0.55A_L}{A_S + A_L}$		$0.5\,(P_w \cdot w + \beta \cdot P_c \cdot c)$
	Double skin side	$\phi_S = 0.5 - \phi_L$	$2\,P_d \cdot d + 2\,P_w \cdot w + P_c \cdot c$	$P_d \cdot d + 0.5\,P_w \cdot w$
	Longl. bhd.	$\phi_L = \dfrac{0.615A_L}{A_S + A_L}$		$0.5\,(P_w \cdot w + \beta \cdot P_c \cdot c)$

Section 5

Openings in Longitudinal Strength Members

5.1 Locations

5.1.1 The keel plate is normally not to have any openings.

In the bilge plate, within 0.6L amidships, openings are to be avoided as far as practicable. Any necessary openings in the bilge plate are to be kept well clear of the bilge keel.

5.1.2 Openings in the strength deck within 0.6L amidships (within the cargo hold region for ships with large hatch openings) are as far as practicable to be located inside the line of large hatch openings. Necessary openings outside this line are to be kept well clear of the ship's side and hatch corners.

Openings in lower decks are to be kept well clear of the main hatch corners and other areas of high stresses.

5.1.3 Openings in the side shell, longitudinal bulkheads and longitudinal girders are not to be located within twice the opening breadth below the strength deck.

5.1.4 Small openings are generally to be kept well clear of other openings in the longitudinal strength members. The transverse distance between any two adjacent unreinforced openings is not to be less than four times the breadth of the larger opening.

5.2 Deductions for openings

5.2.1 Openings exceeding 2.5 m in length or 1.2 [m] in breadth and scallops, where scallop-welding is applied, are to be deducted from the sectional areas used in the section modulus calculation.

5.2.2 Smaller openings (manholes, lightening holes, single scallops in way of seams etc.) need not be deducted provided that the sum of their breadths or shadow area breadths in one transverse section does not reduce the section modulus at deck or bottom by more than 3 per cent and provided that the height of lightening holes, draining holes and single scallops in longitudinals or longitudinal girders does not exceed 25 per cent of the web depth, (for scallops maximum height 75 [mm]). In longitudinals the distance between single openings or group of openings is not to be less than ten times the height of openings.

A deduction free sum of smaller opening breadths or their shadow area breadths in one transverse section in the bottom or deck area equal to 0.06(B-Σb) may be considered equivalent to the above reduction in section modulus (Σb = sum of the breadths of large deductible openings).

The shadow area representing the imaginary longitudinal extension of an opening is obtained by drawing two tangent lines with an opening angle of 30° as shown in Fig.5.2.2.

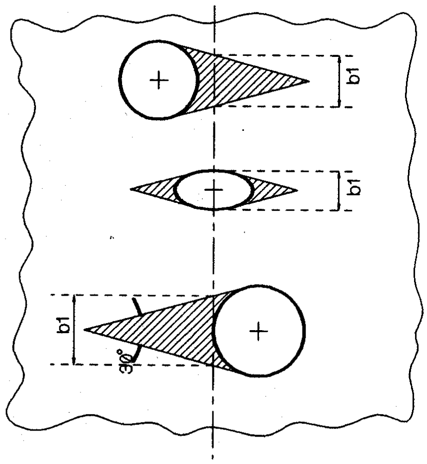


Fig. 5.2.2 : Shadow areas

5.3 Reinforcements

5.3.1 All openings are to be adequately framed; attention is to be paid to structural continuity, and abrupt changes of shape, section or plate thickness are to be avoided. Arrangements in way of corners and openings are to be such as to minimize the creation of stress concentrations.

Corners of hatchways are to be reinforced as given in Ch.9, Sec.2. Smaller openings in the strength deck and outer bottom within 0.6L amidships (within the cargo hold region for ships with large hatch openings) are to be reinforced as given in 5.3.2 to 5.3.5 below. The area of these reinforcements is not to be included in the sectional areas used in the section modulus calculation.

5.3.2 Circular openings with diameter equal to or greater than 0.325 m are to have edge reinforcement. The sectional area A of the edge reinforcement is not to be less than

$$A = 2.5 \text{ b.t. } [cm^2]$$

where,

b = diameter of the opening [m]

t = thickness of the plating [mm].

The reinforcement is normally to be of a vertical ring welded to the plate edge. Alternative arrangements may be accepted provided the reinforcement is within a distance of 0.05b from the plate edge.

5.3.3 Elliptical openings are to have their major axis in the fore and aft direction. Where the ratio of the major axis to minor axis is less than 2 the openings are to be reinforced as given in 5.3.2 taking b as the breadth of the opening (minor axis).

5.3.4 Rectangular openings are to have their corners well rounded. Where corners are of circular shape the radius is not to be less than 20 per cent of the breadth of the opening and the edges are to be reinforced as given in 5.3.2 taking b as the breadth of the opening.

Where corners are of elliptical shape as given in 5.3.3 or of streamlined shape as given in 5.4, the reinforcement will generally not be required provided that the transverse extension of the curvature, a, shown in Fig.5.4.2 is not less than

$$a = 0.15b \ [m]$$

5.3.5 Openings in side shell subjected to large shear stresses are to be of circular shape and are to be reinforced as given in 5.3.2 irrespective of the size of opening.

5.4 Hatchway corners

5.4.1 Where corners are of circular shape, the radius r within 0.6L amidships is not to be less than

$$r = 0.03 \ (1.5 + l / b) \ (B - b) \ [m]$$

where,

l = longitudinal distance between adjacent hatchways [m]

b = breadth of the hatchway [m]

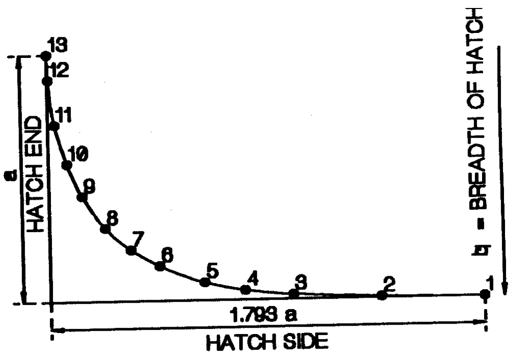
In the above formulae l/b need not be taken as greater than 1.0 and (B - b) is not to be taken as less than 7.5 [m] nor need be taken as greater than 15 [m].

5.4.2 Where corners are of streamlined shape, as given by Fig.5.4.2, the transverse extension of the curvature, a, is not to be less than:

$$a = 0.025 \ (1.5 + l / b) \ (B - b) \ [m]$$

where,

l,b are as defined in 5.4.1.



Ordinates of steamlined corner		
Point	**Abscissa, x**	**Ordinate, y**
1	1.793a	0.0
2	1.381a	0.002a
3	0.987a	0.021a
4	0.802a	0.044a
5	0.631a	0.079a
6	0.467a	0.131a
7	0.339a	0.201a
8	0.224a	0.293a
9	0.132a	0.408a
10	0.065a	0.548a
11	0.022a	0.712a
12	0.002a	0.899a
13	0.0	1.000a

Section 6

Loading Guidance Information

6.1 General

6.1.1 An approved loading manual is to be provided for ships covered by Regulation 10 of the Load Line Convention except those belonging to Category II and of length less than 90 [m] for which the maximum deadweight does not exceed 30% of the displacement at summer loadline draft.

6.1.2 In addition to the Loading Manual all ships of Category I of 100 [m] in length and above are to be provided with an approved loading instrument.

For additional requirements for bulk carriers, ore carriers and combination carriers of $L \geq 150$ [m], see Pt.5, Ch.1.

For chemical carriers and gas carriers existing analog computer may be retained.

6.2 Conditions of approval of loading manuals

6.2.1 The approved Loading Manual is to be based on the final data of the ship. The Manual is to include the design loading and ballast conditions, sub divided into departure and arrival conditions, upon which the approval of the hull scantlings is based.

6.2.2 In case of modifications implying changes in the main data of the ship, a new Loading Manual is to be issued duly approved.

6.2.3 The Loading Manual must be prepared in a language understood by the users. If this language is not English, a translation into English is to be included.

6.3 Conditions of approval of loading instruments

6.3.1 The loading instrument and its operation manual are subject to approval. The approval includes:

- Verification of type approval, if any
- Verification that the final data of the ship has been used
- Acceptance of number and position of read-out points
- Acceptance of relevant limits for all read-out points
- Checking of proper installation and operation of the instrument on board in accordance with the agreed test conditions; and that a copy of the approved operation manual is available.

6.3.2 In case of modifications implying changes in the main data of the ship, the loading instrument is to be modified accordingly and approved.

6.3.3 The operation manual and the instrument output must be prepared in a language understood by the users. If this language is not English, a translation into English is to be included.

End of Chapter

Chapter 6

Bar Keel, Stem and Sternframes

Contents

Section

Section 1

General

1.1 Scope

1.1.1 For ships with various Ice Class notations, additional requirements given in Pt.5, Ch.2 are to be complied with.

1.2 Material

1.2.1 All steel plates and sections, castings and forgings used in the constructions are to be tested and approved in accordance with the requirements of Pt.2, Ch.3, Ch.4 and Ch.5 respectively. Material grades for plates and sections are to be selected as defined in Pt.3, Ch.2.

1.2.2 Bar keels and stems may either be steel castings or steel forgings.

1.2.3 Sternframes, rudder horns and shaft brackets may be constructed of cast or forged steel or may be fabricated from plates.

1.3 Symbols

1.3.1 L, T as defined in Ch.1, Sec.2.

Section 2

Bar Keel

2.1 Scantlings

2.1.1 The scantlings of bar keel are not to be less than :

Depth = 100 + 1.5 L [mm]

Thickness = 10 + 0.6 L [mm]

Minor deviations from the above values may be accepted provided the required sectional area is maintained.

Section 3

Stem

3.1 Bar stem

3.1.1 The cross sectional area 'A' of a bar stem, below the summer load waterline, is not to be less than

$A = 1.2L$ [cm^2] for $L \leq 75$ [m]

$= 1.6L - 30$ [cm^2] for $L \geq 75$ [m]

3.1.2 Above the summer load waterline the cross sectional area of the bar stem may be gradually reduced to 0.75 A [cm^2] at the stem head.

3.2 Plate stem

3.2.1 The thickness 't' of the plate stem below the summer load waterline is not to be less than:

$$t = (0.08\,L + 5.5)\,\sqrt{k}\ \text{[mm]}$$

However 't' need not exceed 25.0 [mm].

3.2.2 The thickness of the plate stem may be gradually reduced to that of the side shell at the stem head.

3.2.3 The plate stems are to be supported by horizontal diaphragms spaced not more than 1.0 [m] apart. Where the stem plate radius is large, a centreline stiffener or web is to be provided.

3.3 Strengthening against bow impact

3.3.1 The region forward of 0.1L abaft of F.P. and above the summer load waterline, is to be strengthened for bow impact pressure 'p_i' [N/mm^2], the design value of which is to be taken as :

$$p_i = (2.2 + 1.5\tan\alpha) \times (0.4V\sin\beta + 0.6\sqrt{L})^2 .10^{-3}\ \text{[N/mm}^2\text{]}$$

In the above formula L need not be taken greater than 250 [m].

V = maximum service speed (knots). as defined in Ch.1, Sec.2.1.10.

α = flare angle, taken as the angle between the side plating and the vertical axis, measured in the plane 'y-y' (see Fig.3.3.1).

β = angle made by the tangent to waterline with the centreline of the ship at the point under consideration. (see Fig.3.3.1).

3.3.2 The scantlings of plates and stiffeners are not to be less than the following :

Plate thickness

$t = 0.028\, f_a\, f_r\, s\, \sqrt{(p_i\, k)} + t_c$ [mm.]

Section modulus of stiffeners

$Z = 0.15\, s\, p_i\, l^2\, k + Z_c$ [cm^3]

where,

s = spacing of stiffeners [mm].

l = span of stiffeners [m].

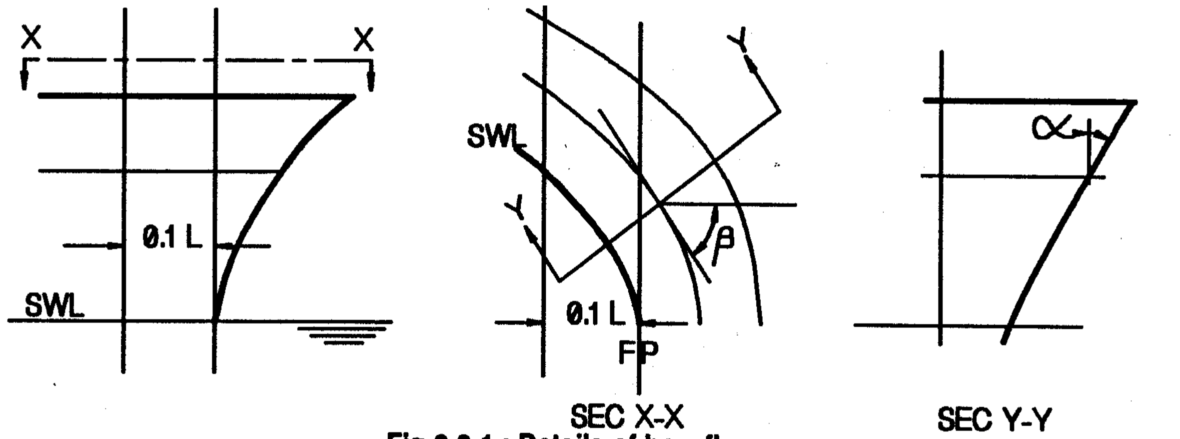


Fig.3.3.1 : Details of bow flare

f_a,f_r are correction factors for aspect ratio and curvature, respectively, as defined in Pt.3, Ch.3.

t_c,Z_c are corrosion additions to thickness and section modulus of stiffeners as defined in Pt.3, Ch.3.

3.3.3 Outside the region specified above, the scantlings of side plating and stiffeners may be gradually reduced to the general requirements.

3.3.4 Stiffeners are to be connected at ends. Where stiffener webs are not perpendicular to the shell plating adequate tripping brackets are to be fitted.

3.3.5 Thickness 't' of primary members is not to be less than:

$$t = (6.5 + 4.75 \sqrt{p_i}) \sqrt{k} + t_c \text{ [mm]}$$

3.3.6 Near the shell plating, the spacing of stiffeners on decks or webs of girders is not to exceed 90 times the thickness of the deck or web plating.

3.3.7 The cross sectional area 'A' of the webs at ends of local girders in the region specified in 3.3.1 is not to be less than :

$$A = 30\ b\ p_i\ S\ k + 0.01\ h\ t_c \text{ [cm}^2\text{]}$$

where,

b = mean breadth, [m], of the load area supported by the girder.

S = Span of the girder, [m].

h = girder height, [mm].

3.4 Bulbous bow

3.4.1 Where a bulbous bow is fitted, the structural arrangements are to be such that the bulb is adequately supported and integrated into the fore peak structure.

3.4.2 At the fore end of the bulb the structure is generally to be supported by horizontal diaphragms spaced not more than 1.0 [m] apart in conjunction with a deep centreline web.

3.4.3 In general, vertical transverse diaphragm plates are to be arranged in way of the transition from the peak framing to the framing of the bulb.

3.4.4 A centreline wash bulkhead is generally to be fitted in way of wide bulbs. Similarly transverse wash bulkheads or substantial web frames spaced approximately 5 frame spaces apart are to be fitted in way of long bulbs.

3.4.5 The shell plating thickness at the fore end of the bulb and in other areas likely to be damaged by the anchors and chain cables is not to be less than that required for plate stems as defined in 3.2.1.

Section 4

Stern Frames and Rudder Horns

4.1 General

4.1.1 Sternframes, rudder horns, shaft brackets etc. are to be designed such that they are effectively integrated into the ship's structure.

4.1.2 In castings, sudden changes of section or possible constrictions to the flow of metal during castings are to be avoided. All fillets are to have adequate radii, which in general should not be less than 50 to 75 [mm], depending on the size of the casting.

4.1.3 Fabricated and cast steel sternframes are to be strengthened at intervals by webs. In way of the upper part of the sternframe arch, these webs are to line up with the floors.

4.1.4 Rudder posts and propeller posts are to be connected to floors of increased thickness.

4.1.5 It is recommended that the after body of the ship be so shaped as to ensure adequate flow of water to the propeller so as to prevent uneven formation of eddies, as far as possible.

For a moderately cavitating propeller the following minimum values of propeller hull clearances may be used as a guidance. (See Fig.4.1.5)

For single screw ships:

$a \geq 0.2\ R$ [m]

$b \geq (0.7 - 0.04\ N_b)\ R$ [m]

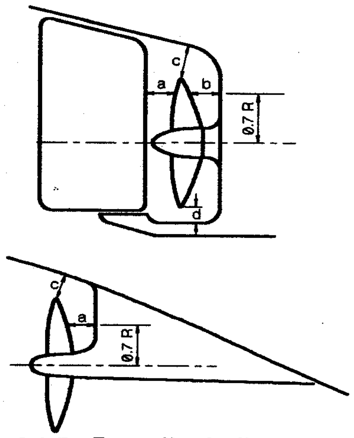


Fig.4.1.5 : Propeller hull clearances

$c \geq (0.48 - 0.02\ N_b)\ R$ [m]

$d \geq 0.07\ R$ [m]

For twin screw ships:

$b \geq (0.5 - 0.03\ N_b)\ R$ [m]

$c \geq (0.6 - 0.02\ N_b)\ R$ [m]

where,

R = Propeller radius [m]

N_b = Number of propeller blades.

4.2 Sternframes

4.2.1 The scantlings of the propeller posts are not to be less than the following:

Forged propeller posts (see Fig.4.2.1 (a))

$A = (10 + 0.5L)\ T$ [cm^2] for L < 60 [m]

$= 40\ T\ k$ [cm^2] for L > 60 [m]

$w = 40\ \sqrt{T}$ [mm]

Fabricated propeller posts (see Fig.4.2.1 (b))

$l = 200\ \sqrt{T}$ [mm]

$w = 140\ \sqrt{T}$ [mm]

$r = 18\ \sqrt{T}$ [mm]

$t_1 = 12\ \sqrt{(Tk)}$ [mm]

$t_w = 6\sqrt{(Tk)}$ [mm], however need not exceed 30 [mm].

Cast steel propeller posts - (See Fig.4.2.1 (c))

$l = 165\ \sqrt{T}$ [mm]

$w = 115\ \sqrt{T}$ [mm]

$r = 20\ \sqrt{T}$ [mm]

$t_1 = 12\sqrt{(Tk)}$, [mm] however not less than 19 [mm].

$t_2 = 16\sqrt{(Tk)}$, [mm] however not less than 25 [mm].

$t_w = 8\sqrt{(Tk)}$, [mm] however need not exceed 38 [mm].

Where the sections adopted differ from the above, the section modulus about the

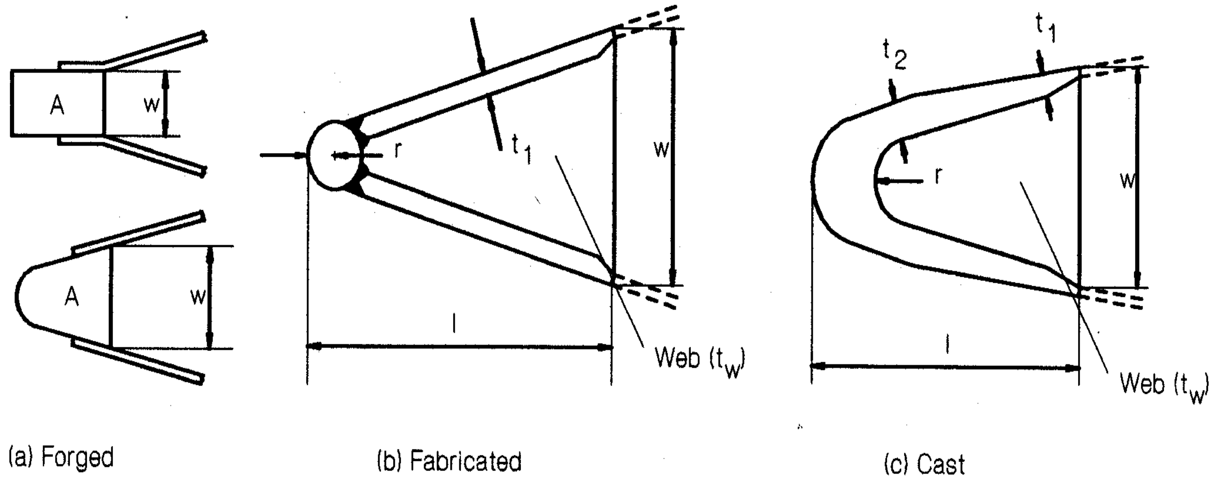


Fig.4.2.1 : Types of propeller posts

longitudinal axis is to be equivalent to that with the Rule scantlings. However the thickness t_1 is neither to be less than (minimum of 19 [mm] for cast steel propeller posts) nor less than $8\sqrt{(Tk)}$ the increased thickness of shell plating adjacent to sternframe.

On sternframes without solepieces, the modulus of the propeller post, about the longitudinal axis, may be gradually reduced by 15 per cent below the propeller boss, provided the thicknesses are maintained as above.

4.2.2 The wall thickness of the boss 't_b' in the propeller post is not to be less than :

$t_b = 0.16\ d_{ts} + 30$ [mm] for $d_{ts} \leq 300$ [mm]

$= 5\ \sqrt{(d_{ts} - 60)}$ [mm] for $d_{ts} > 300$ [mm]

where,

d_{ts} = Rule diameter of tail shaft, [mm].

In fabricated stern frames the connection of the propeller post to the boss is to be by full penetration welds.

4.2.3 The section modulus of the rudder post 'Z_T' about the longitudinal axis is not to be less than:

$$Z_T = \frac{F_r l}{1000}\ [\mathrm{cm}^3]$$

where,

F_r = Rudder force [N] as defined in Pt.3, Ch.14, Sec.3.

l = Unsupported span of the rudder post, [m] (See Fig.4.2.3).

Where, due to low rigidity of the sole piece in the transverse direction, the bottom support for the rudder post can not be regarded as efficient, direct calculations are to be carried out and the section modulus of the rudder post increased to limit the bending stress to 85 [N/mm^2].

4.2.4 The diameter of rudder shaft 'dl', at the lower bearing is not to be less than :

$$d_l = 3.9\ \sqrt[3]{\left(\frac{F_r\ .c\,(l - c)}{l} k\right)}\ [\mathrm{mm}]$$

where,

F_r = Rudder force [N] as defined in Pt.3, Ch.14, Sec.3

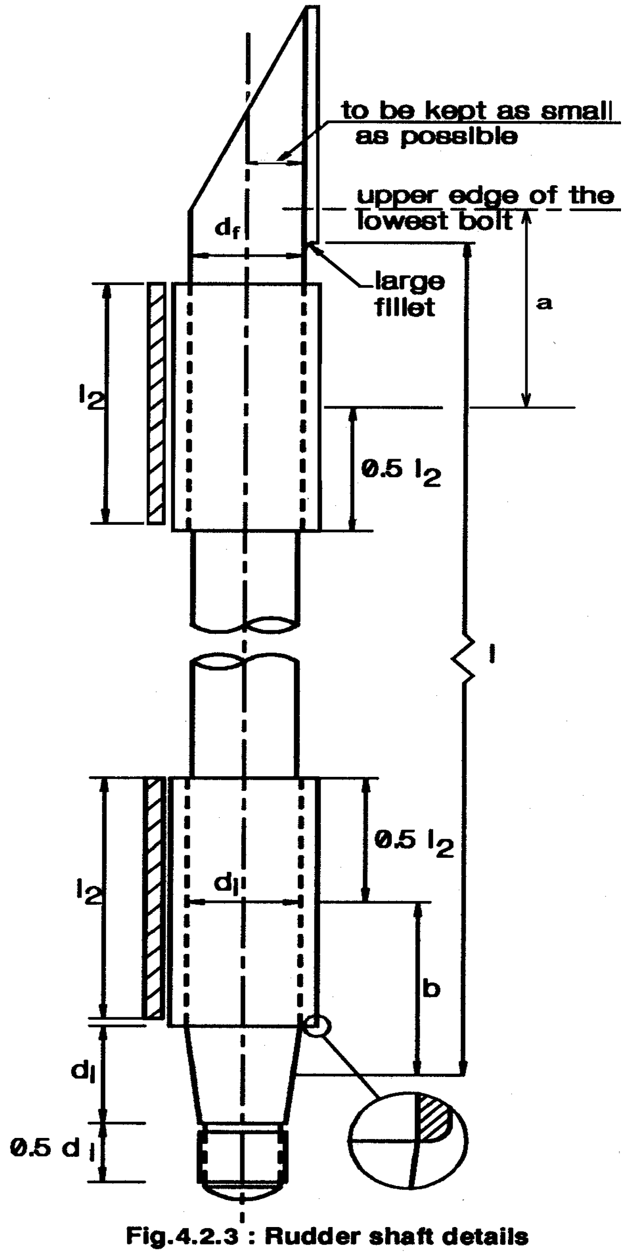


Fig.4.2.3 : Rudder shaft details

$$c = \frac{a + b}{2}$$

a, b and l are as given in Fig.4.2.3, [m].

The diameter 'd_l' may have to be increased on account of low rigidity of sole piece, as described for the rudder post in Sec.4.2.3.

The diameter d_f below the coupling flange is to be 10 per cent greater than dl unless the rudder axle is protected by a corrosion-resistant composition above the upper bearing.

The details of taper, nut etc. at the lower end of the rudder axle, are to be similar to those of rudder stock cone couplings given in Ch.14.

The scantlings and arrangements of vertical coupling at the upper end of the rudder axle are to be similar to those of horizontal bolted couplings of rudder given in Pt.3, Ch.14, Sec. 6.1. In the formula the axle diameter 'd_l' is to be used in place of rudder stock diameter 'd_s'.

The bearing depth l_2 is not to be less than 1.2 d_l [mm].

4.3 Sole piece

4.3.1 Requirements for structural strength of sole pieces are given in Pt.3, Ch.14.

4.3.2 The sole piece is to extend at least two frame spaces forward of the forward edge of the propeller boss and beyond this the cross section of the extension is to be gradually reduced to that necessary for an efficient connection to the keel plate. Fabricated solepieces are to have adequate internal stiffening.

4.4 Shaft brackets

4.4.1 Where the propeller shafting is exposed to the sea for some distance clear of the main hull, it is generally to be supported adjacent to the propeller by independent brackets having two arms. It is recommended that the angle included between the arms differs from the angle included between the propeller blades. In very small ships the use of single arm brackets will be considered.

4.4.2 Fabricated brackets are to be designed to avoid or reduce the effect of hard spots and ensure a satisfactory connection to the hull structure. The connection of the arms to the bearing boss is to be by full penetration welding.

4.4.3 Generally bracket arms are to be carried through the shell plating and attached to floors or girders of increased thickness. The shell plating in way of shaft brackets is to be increased in thickness to a minimum of 1.5 times the Rule bottom shell plating thickness amidships. In way of struts, an insert plate is to be provided of thickness not less than:

$t = 1.9 \sqrt{d_{ts}}$ where d_{ts} is the tailshaft diameter. The connection of the struts to the shell plating is to be by full penetration welding.

4.4.4 The scantlings of solid or built-up shaft brackets are to comply with the following:

$t = 0.4 \, d_{ts}$ [mm]

$A = 4.5 \, d_{ts}^2 \, . \, 10^{-3}$ [cm^2]

$Z_T = 30 \, d_{ts}^3 \, . \, 10^{-6}$ [cm^3]

where,

t = thickness of the strut

A = cross sectional area of the strut

Z_T = Section modulus of the strut against transverse bending.

4.5 Rudder horns

4.5.1 Requirements for structural strength of rudder horns are given in Pt.3, Ch.14.

4.5.2 Rudder horns supporting semi-spade type rudders are to be efficiently integrated into the main hull structure, and additional web frames or side transverses may be required in the 'tween deck above.

4.5.3 The shell plating is to be increased in thickness in way of the horn, and the radius at the shell connection is not to be less than (150 + 0.8L) [mm].

Section 5

Propeller Nozzles

5.1 General

5.1.1 The requirements for scantlings and arrangements of propeller nozzles given in this section apply, in general, to nozzles of numeral N_N, not greater than 200. Nozzles of numeral greater than 200 will be specially considered.

Nozzle numeral $N_N = 0.01$ P.D

where,

P = Power transmitted to the propeller [kW]

D = Diameter of the propeller [m].

Additional requirements for scantlings and arrangements applicable to steerable nozzles and fixed nozzles are given in 5.3 and 5.4 respectively.

For additional requirements applicable to Azimuth Thrusters see Pt.4, Ch.4, Sec.9.

5.1.2 All materials used in the construction of the nozzle-body, stocks, pintles, keys and bolts are to be similar to rudders as per Ch.14, Sec.1.

5.2 Nozzle scantlings and construction details

5.2.1 Nozzle scantlings are to be as per Table 5.2.1.

Table 5.2.1 : Nozzle scantling requirements

Item		Requirement
1)	Shroud plating in way of propeller blade tips	- For $N_N \leq 63$ $t_s = (11 + 0.1\ N_N)$ [mm] - For $N_N > 63$ $t_s = (14 + 0.052\ N_N)$ [mm]
2)	Shroud plating clear of blade tips, flare and cone plating, wall thickness of leading and trailing edge members	$t_p = (t_s - 7)$ [mm] but not less than 8 [mm]
3)	Webs and ring webs - iwo head box and pintle support - elsewhere	 $t_w = (t_s + 4)$ [mm] As for item (2)
Symbols		
N_N = Nozzle numeral as given in 5.1.1 t_s = thickness of shroud plating in way of propeller tips [mm] t_p = thickness of plating [mm] t_w = thickness of webs and ring webs in way of headbox and pintle support [mm]		
NOTE : Thickness given are for mild steel. When corrosion resistant material is used, the plate thicknesses may be reduced by 15%, however, thickness is not to be less than minimum thickness as applicable.		

5.2.2 If the ship has ice class notation, nozzle scantlings will be specially considered; however, the part of the outer shell of the nozzle which is situated within the ice belt is to have a plate thickness not less than that of the shell plating in way.

5.2.3 The shroud plating in way of the propeller tips is to be carried well forward and aft of the propeller tips, due allowance being made on steering nozzles for the rotation of the nozzle in relation to the propeller, however, shroud plate width is not to be less than $(L_N/4)$, where L_N is the length of the nozzle (See Fig.5.2.3).

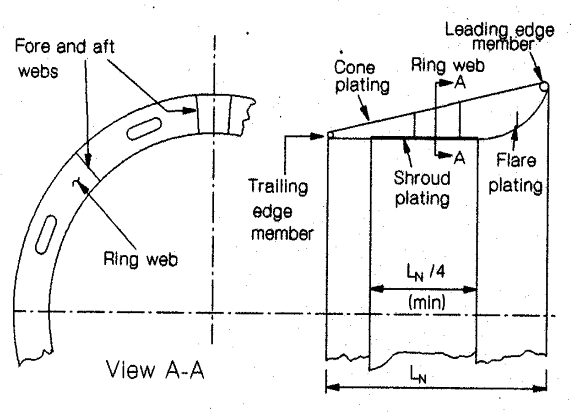


Fig.5.2.3 : Nozzle sectional views

5.2.4 The transverse strength of the nozzle is to be maintained by fitting adequate number of ring webs. At least two ring webs are to be fitted in way of shroud plating, spaced approximately 400 [mm]. Fore and aft of these webs the spacing of ring webs is generally not to exceed 600 [mm]. Ring webs are to be increased in thickness in way of the headbox and pintle support structure in accordance with Table 5.2.1 and the increased thickness is to be maintained to the adjacent fore and aft web.

5.2.5 Local stiffening is to be fitted in way of the top and bottom supports which are to be integrated with the webs and ring webs. Continuity of bending strength is to be maintained in these regions.

5.2.6 Weld details of nozzle plating, webs, coupling flanges etc. are to be as given in Sec.4 of Ch.14 'Rudders' and also as per Ch.17 'Welding'.

5.2.7 Leak testing of the nozzle is to be as required for rudders as per Ch.18.

5.2.8 Arrangement is to be provided to drain the nozzle completely. Drain plugs are to be provided with efficient packing.

5.2.9 Internal surfaces of nozzles are to be efficiently coated for corrosion protection after completion of fabrication and testing. Where it is intended to fill the nozzle with plastic foam, details of the foam material is to be submitted.

5.3 Steerable nozzles

5.3.1 The nozzle stock, couplings, pintles and bearings are to be designed analogusly with the requirements given in Ch.14, Sections 5 and 6 using the design values of lateral force, Fr and turning moment Qr as given below:

$$Fr = 376\ A\ .\ V^2\ [N]$$

$$Qr = Fr\ .\ r\ [N\text{-}m]$$

where,

A = projected area of nozzle [M^2]

V = Maximum service speed [knots] with the ship on summer load waterline. When the speed is less than 10 knots. V is to be replaced by the expression Vmin = (V + 20)/3.

r = the horizontal distance from centre line of stock to centre of pressure of nozzle, but not to be taken less than 10% of the chord length of the nozzle.

5.3.2 Effective means are to be provided for supporting the weight of the nozzle. Where the support is provided by a carrier bearing attached to the nozzle head, the structure in way of the bearing is to be adequately strengthened. The shell plating in way of nozzle head is to be increased in thickness by 50%.

5.3.3 All nozzle bearings are to be accessible for measuring wear without lifting or unshipping the nozzle.

5.3.4 Satisfactory arrangement is to be provided to prevent water from entering the steering gear compartment and lubricant from being washed away from the nozzle carrier. A seal or stuffing box is to be fitted above the deepest load water line for this purpose, however, two separate seals or stuffing boxes are to be provided when the nozzle carrier is below the deepest load water line.

5.4 Fixed nozzles

5.4.1 The nozzle is to be adequately supported preferably by closed box structures of necessary enclosed area to withstand the lateral force Fr and Torque Qr given in 5.3.1 and its own weight. The resultant stresses are not to exceed the following:

Bending stress σ_b = 75/k [N/mm^2]

Torsional shear stress τ_t = 50/k [N/mm^2]

Shear stress τ = 50/k [N/mm^2]

Equivalent stress

$$\sigma_{e1} = \sqrt{\sigma^2 + 3\tau^2} = 100/\mathrm{k}\ [\mathrm{N/mm}^2]$$

$$\sigma_{e2} = \sqrt{\sigma + 3\tau_\tau{}^2} = 90/\mathrm{k}\ [\mathrm{N/mm}^2]$$

5.4.2 The nozzle support box structure is to be well integrated to the webs and ring webs in the nozzle and to the hull structure. Structural continuity is to be maintained between the webs in the nozzle, the top box structure and local girders/floors inside the hull.

End of Chapter

Chapter 7

Bottom Structure

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The scantlings and arrangement of bottom structure as defined in Ch.1, Sec.2 are to comply with the requirements given in this Chapter.

1.2 Symbols

L,B,T,C_b,k as defined in Ch.1, Sec.2.

t_c,Z_c are corrosion additions to the thickness and section modulus respectively, as given in Ch.3, Sec.2.1.

f_a,f_r are correction factors for aspect ratio and curvature, respectively, as defined in Ch.3, Sec.3.1.

C_w, a_o, k_v and k_s as defined in Ch.4, Sec.1.2, Sec.2.3 and Sec.3.2.

T_b = lowest design ballast draught amidships, [m]. For preliminary purposes, T_b may be taken as 0.35T for cargo vessels and (2+0.02L) for tankers.

s = spacing of stiffeners, [mm]

l = span of stiffeners, [m]

b = spacing of girders, [m]

S = span of girders, [m]

$$f_B = \frac{Z_R}{Z_B}$$

where,

Z_R = Rule midship section modulus [cm^3] as required by Ch.5, Sec.3.3.1.

Z_B = Actual midship section modulus [cm^3] provided at bottom.

$$f_z = \frac{z}{z_n}$$

where,

z_n = vertical distance [m], from the neutral axis of the hull girder to the base line.

z = vertical distance [m], from the neutral axis of hull girder to the free flange of the stiffener or girder.

Section 2

Structural Arrangement and Details

2.1 General

2.1.1 Except as specified in 2.1.6, passenger ships and cargo ships other than tankers, are to be fitted with a double bottom extending from the collision bulkhead to the after peak bulkhead as far as this is practical and compatible with the design and proper working of the ship.

Note: For the purpose of this requirement, a “tanker” is a cargo ship constructed or adapted for the carriage in bulk of liquid cargoes of an inflammable nature.

For oil tankers, chemical carriers and liquefied gas carriers, the requirements indicated in Pt.5, Ch.2, Ch.3 and Ch.4 respectively regarding double bottom and location of wells above bottom shell are to be complied with.

2.1.2 Where a double bottom is required to be fitted, its depth is to be as per 6.1.1 and the inner bottom is to be continued to the ships side in such a manner as to protect the bottom to the turn of the bilge.

2.1.3 Small wells constructed in the double bottom, in connection with the drainage arrangement of holds, are not to extend in depth more than necessary. A well extending to the outer bottom, may be permitted at the after end of the shaft tunnel of the ship. Other wells may be considered provided the arrangements give protection equivalent to that offered by a double bottom. In no case the vertical distance from the bottom of such a well to the plane coinciding with the keel line be less than 500 [mm].

2.1.4 A double bottom need not be fitted in way of watertight compartments used exclusively for the carriage of liquids, provided the safety of the ship is not impaired in the event of bottom damage.

2.1.5 Any part of a passenger ship or a cargo ship other than tanker that is not fitted with a double bottom in accordance with 2.1.1 or 2.1.4 is to be capable of withstanding bottom damages as specified in para 8 of SOLAS II-1 Reg.9.

2.1.6 A double bottom need not be fitted on the following ships:

(a) Cargo ships of less than 500 tons gross tonnage.

(b) Ships not propelled by mechanical means.

(c) Fishing vessels.

2.1.7 The engine room of all ships having L > 90 [m] is to have a double bottom.

2.1.8 For ships of L > 90 [m], single bottoms within the cargo region, where permitted, are normally to be longitudinally stiffened.

2.1.9 For ships of L > 150 [m] and for ships strengthened for heavy cargoes, double bottoms within the cargo region are normally to be longitudinally stiffened.

2.1.10 The continuity of the bottom, bilge and inner bottom longitudinals is to be maintained in accordance with Ch.3, Sec.5.1.1.

2.1.11 The bilge keel and the ground bar to which it is attached, are to be gradually tapered at ends and arranged to finish in way of suitable internal stiffening. Butt welds in the bilge keel and the ground bar are to be well clear of each other and those in the shell plating.

2.1.12 The weld connections are to comply with the requirements of Ch.17.

2.2 Access ventilation and drainage

2.2.1 Adequate access is to be provided to all parts of the double bottom. The vertical dimension of lightening holes is not to exceed 50 per cent of the girder height. The diameter of lightening holes in the bracket floors is not to exceed 1/3 of the breadth of the brackets. Lightening holes or manholes are normally not to be cut in floors or girders towards their ends and under large pillars or supporting structures. Manholes in inner bottom are to have reinforcement rings, and the man hole covers in the inner bottom plating in cargo holds are to be effectively protected. The edges of all holes are to be smooth.

2.2.2 To ensure the free passage of air and water from all parts of the tanks to air pipes and suctions, air and drain holes are to be provided in all non-watertight members. The air holes are to be placed as near to the inner bottom as possible and their total area is to be greater than the area of the filling pipes. The drain holes are to be placed as near to the bottom as possible.

2.2.3 The access opening to pipe tunnel is to be visible above the floor plates and is to be fitted with a rigid watertight closing device. A notice board stating that the access opening to the pipe tunnel is to be kept closed, is to be fitted near the opening. The opening is to be regarded as an opening in watertight bulkhead.

Section 3

Design Loads

3.1 Bottom shell

3.1.1 The design pressure 'p' on outer bottom is to be taken as

$p = 0.01T + (k_s - 1.5)\ C_w\ R_s\ .\ 10^{-3}$ [N/mm^2].

In way of tanks, the design pressure is not to be taken less than net internal pressure 'p_i' given below:

p_i = Internal pressure in tanks as given in Ch.4, Sec.3.3.2 less applicable external sea pressure as given in Ch.4, Sec.3.2.4.

Net 'p_i' on the outer bottom for vessels of L < 90 [m], may be approximated as:

$p_i = 0.01\ (h_s - T_b) + p_o$ [N/mm^2]

where,

h_s = vertical distance [m], from the load point to top of the tank.

p_o = 0.01 [N/mm^2] for L $\leq$ 20 [m]

= 0.024 [N/mm^2] for L $\geq$ 90 [m].

For L between 20 [m] and 90 [m], 'p_o' is to be obtained by linear interpolation.

However, in mechanically propelled cargo ships of 500 GT and above and passenger ships, for tanks forming part of the watertight subdivision, (See Ch.10, Cl.4.2.1) p_0 is to be taken as not less than 0.024 [N/mm^2].

3.2 Watertight floors and girders

3.2.1 The design pressure 'p' on watertight floors and girders in double bottom tanks is to be taken as the greater of:

$p = 6.7\ h_p \times 10^{-3}$ [N/mm^2]

$p = 0.01\ h_s + p_o$ [N/mm^2]

$p = 0.01\ D_f$ [N/mm^2]

where,

h_p = vertical distance [m], from the load point to the top of air pipe.

h_s, p_o as given in 3.1.1.

D_f = depth to freeboard deck [m].

3.3 Inner bottom

3.3.1 The design pressure 'p' on the inner bottom is to be taken as the greater of that given in 3.2.1 and the following:

- In way of cargo holds, the design pressure 'p' is not to be taken as less than:

$$p = \rho.H.\left(1 + 0.5\frac{k_v a_o}{C_b}\right).10^{-2}\ [\mathrm{N/mm^2}]$$

where,

ρ = cargo density [t/m^3] normally not to be taken as less than 0.7 [t/m^3]

H = height [m], to tween deck or top of hatchway coaming.

- In way of holds for ballast, the design pressure is not to be taken as less than:

$$p = h_s\ .\left(1 + 0.5\frac{k_v a_o}{C_b}\right).10^{-2}\ [\mathrm{N/mm^2}]$$

where,

h_s = vertical distance [m], from inner bottom to top of hatch coaming.

Section 4

Bottom and Inner Bottom Plating

4.1 Keel plate

4.1.1 The width of the plate keel is not to be less than (800+5L) [mm], nor greater than 1800 [mm]. The thickness is to be 2 [mm] greater than that required for the adjacent bottom plating.

4.2 Bottom, bilge and inner bottom plating

4.2.1 The thickness 't' of the bottom plating is not to be less than the minimum requirement given in 4.2.2, nor less than:

$$t = f_a \, . f_r \, . \frac{s\sqrt{p}}{2\sqrt{\sigma}} + t_c \; [\text{mm}]$$

where,

p = applicable design pressure, [N/mm^2], as given in 3.1.1 and 3.3.1 for outer bottom and inner bottom respectively.

s = stiffener spacing, [mm].

σ = allowable bending stress, [N/mm^2], as per Table 4.2.1.

Table 4.2.1 : σ values for bottom, bilge and inner bottom plating [N/mm^2]

		Single Bottom	Double Bottom	
Region	Framing	Bottom and bilge	Bottom and bilge	Inner bottom 1)
0.4L amidships	Transverse	($175-120f_B$)/k max. 120/k	($170-120 f_B$)/k max. 120/k	($200-110f_B$)/k max. 160/k
	Longitudinal	($185-100f_B$)/k max. 120/k	($180-100f_B$)/k max. 120/k	($220-100f_B$)/k max. 160/k
Within 0.1L from ends	160/k			
Elsewhere	To be obtained by linear interpolation between allowable values at regions specified above			

Note : 1) In way of hold tanks amidships intended for ballast or cargo oil the value of σ is to be reduced by 10/k [N/mm^2]

4.2.2 The minimum thickness requirement of the bottom and inner bottom plating is given by

t = (t_o+0.04L) $\sqrt{k}$ + t_c [mm] for bottom plating

= (t_o+0.03L) $\sqrt{k}$ + t_c [mm] for inner bottom plating.

L need not be taken as more than 250 [m].

t_o = 5.0 [mm], in general.

= 7.0 [mm], for inner bottom plating below dry cargo hatchway openings where ceiling is not fitted.

= 6.0 [mm], for inner bottom plating elsewhere where ceiling is not fitted.

4.2.3 The bottom bilge and inner bottom plating is also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

For ships of L > 90 [m], the thickness of these platings within 0.4L amidships, corresponding to the buckling strength requirement may be approximated as :

- For longitudinally stiffened plating

$$t = \frac{0.009s\sqrt{k}}{\sqrt{(1 - 0.75 f_B . f_z)}} + t_c \text{ [mm]}$$

- For transversely stiffened plating

$$t = \frac{0.0164s\sqrt{k}}{[1 + (s/1000l)^2]\sqrt{(1 - 0.75 f_{B.} f_z)}} + t_c \text{ [mm]}$$

4.2.4 For ships discharged by grabs, the plating thickness 't' of the inner bottom and exposed parts of sloping bulkheads is not to be less than:

t = 0.0115 (s+800) √k + t_c [mm]

Where ceiling is fitted, the above requirement may be reduced by 2 [mm].

4.2.5 Where the inner bottom is subjected to wheel loads from cargo handling vehicles, the scantlings are also to comply with the requirements given in Ch.9, Sec.6.

Section 5

Single Bottom

5.1 Transverse framing

5.1.1 Plate floors of following scantlings are to be fitted at every frame

depth at centre line, d = 40(B+T) [mm]

thickness of web, t = (d/100+3) √k [mm]

face plate area, a = 3.5 T.√k [cm^2]

The thickness of face plate is not to be less than 1/15 of the face width.

The top of floors, in general, is to be level from side to side. However, in ships having considerable rise of floor, the depth of web at 10 per cent of the span from ends, is not to be less than 1/2 d [mm].

5.1.2 On all ships one centre girder is to be fitted and in addition side girders are to be fitted such that the spacing of girders does not exceed 2.5 [m]. The girders are to extend as far forward and aft as practicable and where they are cut at transverse bulkheads the longitudinal strength is to be maintained. Where the bottom structure changes into a double bottom structure, the bottom girders are to extend at least 3 frame spaces into double bottom structures.

The scantlings of the bottom girders, within 0.5L amidships, are not to be less than the following:

Centre girder -

web thickness, t = (5.5+0.06L) √k [mm]

face plate area, a = (5+0.65L)k. [cm^2]

Side girders -

web thickness, t = (5+0.04L) √k [mm].

face plate area, a = (5+0.35L)k [cm^2].

The thickness of face plates is not to be less than 1/15 of the face width.

Towards the fore and after ends, the scantlings of the bottom girders may be reduced by 10 per cent.

5.1.3 In the engine room, the thickness of floors webs and the face plate area as given in 5.1.1 are to be increased by 1 [mm] and 50 per cent respectively. The floors are not to be flanged.

If the height of floors is reduced in way of crankcase, the face plate area is to be suitably increased, however the reduced height is normally not to be less than 2/3 of 'd' as given in 5.1.1.

5.1.4 In the after peak of single screw ships, the height of the floors is to be increased such that their upper edge is well above the stern tube.

5.1.5 Where single bottom in the cargo region is stiffened by transverse frames supported by longitudinal girders, the scantlings of the frames and longitudinal girders are to be determined in accordance with 6.2.3 and 5.2.3, 5.2.4 respectively.

5.2 Longitudinal framing

5.2.1 The spacing of bottom transverses is normally not to exceed the greater of 0.02L [m] or 3.6 [m]. The bottom transverses are to be supported by primary girders or longitudinal bulkheads. Where the design does not incorporate a centreline bulkhead, at least a docking girder is to be provided. The scantlings of simple girders and transverses are to be obtained in accordance with 5.2.3. The scantlings of a complex girder system are to be based on a direct stress analysis.

5.2.2 The section modulus 'Z' of the bottom longitudinals is not to be less than:

$$Z = \frac{s\,p\,l^2 .10^3}{12\sigma} + Z_c \ \ [cm^3]$$

where,

p = applicable design pressure as given in 3.1.1.

σ = (215 - 135f_B.f_z)/k, max.160/k [N/mm^2] within 0.4L amidships

= 160/k [N/mm^2] within 0.1L from ends.

Elsewhere σ may be obtained by linear interpolation.

The longitudinals are also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

5.2.3 The section modulus 'Z' of bottom girders is not to be less than:

$$Z = \frac{10^6\, b\,p\,S^2}{m\sigma} + Z_c \ \ [cm^3]$$

where,

m = 10 in general

p = applicable design pressure as given in 3.1.1.

σ = (190 - 135 f_B.f_z)/k, max. 160/k [N/mm^2]
for continuous longitudinal girders within 0.4L amidships.

= 160/k [N/mm^2]
for longitudinal girder within 0.1L from ends and for transverse girders in general.

Elsewhere σ may be obtained by linear interpolation.

5.2.4 The effective cross sectional area 'A' of the girder web at ends obtained as per Ch.3, Sec.4.4 is not to be less than:

A = 70 S b p k + 0.01h.t_c [cm^2]

where,

h = girder height [mm].

The web area at middle of the span is not to be less than 0.5A.

5.2.5 The girders are to be satisfactorily stiffened against buckling in accordance with the requirements given in Ch.3, Sec.6. Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.

Section 6

Double Bottom

6.1 General

6.1.1 Where double bottom spaces are used as tanks, the centre girder is to be watertight unless the double bottom is divided by watertight side girders or the tanks are narrow.

The depth 'd' of the centre girder is not to be less than:

d = 250 + 20B + 50T [mm], with a minimum of 760 [mm].

In addition to the above, for passenger ships and cargo ships other than tankers (See 2.1.1) :

d = 50 B [mm], which need not be taken more than 2000 [mm].
In case of ships with considerable rise of floors the depth 'd' may have to be increased.

6.1.2 The thickness 't' of the bottom girders and floors is not to be less than

t = (0.008d + 4) √k [mm], for centre girder;

t = (0.008d + 1) √k [mm], for side girders and plate floors.

6.1.3 The thickness 't' of girders and floors forming boundaries of double bottom tanks is not to be less than that obtained from 6.1.2 and that given below:

$$t = \frac{s\sqrt{p}}{2\sqrt{\sigma}} + t_c \ [mm]$$

where,

p = design pressure as given in 3.2.1.

σ = (200 - 100 f_B)/k, max. 160/k [N/mm^2], for longitudinally stiffened longitudinal girders within 0.4L amidships

= (185 - 115 f_B)/k, max.160/k [N/mm^2], for vertically stiffened longitudinal girders within 0.4L amidships

= 160/k [N/mm^2] for longitudinal girders within 0.1L from ends, and for plate floors.

Between the regions specified above, σ may be obtained by linear interpolation.

6.1.4 The section modulus 'Z' of the stiffeners on girders and floors forming boundaries of double bottom tanks is not to be less than

$$Z = \frac{spl^2 .10^2}{\sigma} + Z_c \ [cm^3]$$

where,

p = design pressure as given in 3.2.1;

σ = (210 - 120 f_B)/k, max. 160/k [N/mm^2] for longitudinal stiffeners within 0.4L amidships

= 160/k [N/mm^2] for longitudinal stiffeners within 0.1L from ends and for transverse or vertical stiffeners in general.

Between the regions specified above σ for longitudinal stiffeners may be obtained by linear interpolation.

Longitudinal stiffeners are to have end connections, other stiffeners may be sniped at ends provided the section modulus Z is increased by 25 per cent.

6.1.5 The longitudinal girders are to be satisfactorily stiffened against buckling in accordance with the requirements given in Ch.3, Sec.6.

6.2 Transverse framing

6.2.1 The side girders are normally to be fitted at a spacing not exceeding 4.0 [m] and are to be extended as far forward and aft as practicable. The girders are to be stiffened at every bracket floor by a vertical stiffener of depth same as that of reverse frame and thickness that of the girder.

6.2.2 Plate floors are to be fitted under bulkheads, pillars, thrust seating, boiler bearers and in way of change of depth of double bottom. In engine room, plate floors are to be fitted at every frame. Elsewhere the spacing of plate floors is not to exceed that given by Table 6.2.2.

Table 6.2.2 : Spacing of plate floors (Transverse framing)

Draught T [m]	Under deep tanks (See Note 1)	Clear of deep tanks (maximum 3.0 [m])
$T \leq 2$	Every 4th frame	Every 6th frame
$2 < T \leq 5.4$	Every 3rd frame	Every 5th frame
$5.4 < T \leq 8.1$	Every 3rd frame	Every 4th frame
$T > 8.1$	Every 2nd frame	Every 3rd frame
Note 1 : Under tanks with height greater than 0.7 times the distance between inner bottom and main deck		

6.2.3 Where bracket floors are fitted the section modulus 'Z' of the bottom frames and reverse frames is not to be less than:

$$Z = \frac{spl^2\ k}{1.6} + Z_c \ [cm^3]$$

where,

p = applicable design pressure as given in 3.1.1 and 3.3.1 for bottom frames and reverse frames respectively.

l = span of frames [m] measured between girder or brackets.

Where vertical struts according to 6.2.4 are fitted, the section modulus of bottom and reverse frames may be reduced by 35 per cent.

6.2.4 The cross sectional area 'A' of the struts is not to be less than

$A = c \cdot k \cdot l \cdot s \cdot T \cdot [cm^2]$

where,

$c = 7 \times 10^{-4}$ in way of ballast tanks

$= 6 \times 10^{-4}$ elsewhere

l = actual span [m], without considering the strut.

The moment of inertia I of the struts is not to be less than

$I = 2.5\ A \cdot d^2 \times 10^{-6}\ [cm^4]$

where,

d = depth of double bottom, [mm].

6.2.5 The bottom frames and reverse frames are to be attached to the centre girder and margin plate by means of brackets of same thickness as that of the plate floors. The breadth of the brackets is not to be less than 0.75 times the depth of the centre girder and the brackets are to be flanged 75 [mm] at their free edges.

6.3 Longitudinal framing

6.3.1 The side girders are normally to be fitted at a spacing not exceeding 5.0 [m] and are to be extended as far forward and aft as practicable.

6.3.2 The plate floors are to be fitted under bulkheads, pillars, thrust seating and boiler bearers. In engine room, plate floors are to be fitted at every second side frames. Additionally, under the main engine seatings, floors extending to the first side girder outside the engine seating, are to be fitted at intermediate frames. Under deep tanks with height greater than 0.7 times the distance between inner bottom and main deck, the spacing of floors is normally not to exceed 2.5 [m]. Elsewhere, the spacing is normally not to exceed 3.6 [m].

6.3.3 The plate floors are to be stiffened at every longitudinal by a vertical stiffener of depth same as that of the inner bottom longitudinal and thickness as that of the floor. Between plate floors, transverse brackets are to be fitted at every frame at the margin plate and at a spacing not exceeding 1.25 [m] on either side of the centre girder. The thickness of brackets is to be same as that of the plate floors. The brackets are to extend upto the adjacent longitudinal and are to be flanged 75 [mm] at their free edges.

6.3.4 The section modulus 'Z' of the bottom and inner bottom longitudinals is not to be less than

$$Z = \frac{spl^2\ .10^3}{12\sigma} + Z_c \ [cm^3]$$

where,

p = applicable design pressure as given in 3.1.1 and 3.3.1 for bottom longitudinals and inner bottom longitudinals respectively;

l = span of longitudinals [m], measured between the plate floors

$\sigma = (210 - 135\ f_B.f_z)/k$ [N/mm^2], max. 160/k [N/mm^2], within 0.4L amidships generally

$= (185 - 135\ f_B.f_z)/k$ [N/mm^2], max. 160/k [N/mm^2] within 0.4L amidships, for inner bottom longitudinals in way of holds/tanks intended for ballast/cargo oil;

= 160/k [N/mm^2] within 0.1L from ends.

Between the regions specified above, σ may be obtained by linear interpolation.

Where vertical struts according to 6.2.4 are fitted, the section modulus of the bottom and inner bottom longitudinals may be reduced by 35 per cent.

Section 7

Additional Strengthening against Slamming

7.1 General

7.1.1 Where the minimum design ballast draught at F.P. is less than 0.04L [m] (maximum 8.5 [m]), the bottom forward is to be additionally strengthened as given in Sec.7.2 and Sec.7.3.

7.1.2 Where the shape of the after sections is such that there are large flat areas of bottom shell, additional stiffening and/or increased shell plate thickness may be required.

7.1.3 Where a ship is classed for 'Restricted Service' or 'Sheltered water service', compliance with the requirements of this section may be modified or waived altogether.

7.2 Spacing of floors and girders

7.2.1 The floors and girders in the region forward of 0.25L abaft of F.P. are to be spaced as given in 7.2.2 and 7.2.3.

7.2.2 Where transverse framing is adopted, floors are to be fitted at every frame. The spacing of longitudinal girders is not to exceed 3 times the transverse frame spacing. In addition, intermediate half height girders or equivalent longitudinals are to be fitted.

7.2.3 Where longitudinal framing system is adopted, the plate floors are to be fitted at alternate frames. The spacing of longitudinal girders is not to exceed 3 times the longitudinal frame spacing. In case of longitudinally stiffened single bottoms, the arrangements and scantlings will be specially considered.

7.3 Plating and stiffeners

7.3.1 The scantlings of bottom plating, stiffeners and girders upto (0.05 T_{bf}) above base line (upto bilge curvature in case of ships with rise of floor) are to be based on the design slamming pressure P_{SL} given below:

P_{SL} = 0.162 $\sqrt{L}$. c_1 . c_2 . c_s [N/mm^2]

for L $\leq$ 150 [m]

P_{SL} = 1.984 (1.3 - 0.002L) c_1 . c_2 . c_s [N/mm^2]

for L > 150 [m];

where,

$$c_1 = 3.6 - 6.5\left[\frac{T_{bf}}{L}\right]^{0.2}$$

c_1 need not be taken more than 1.0

T_{bf} = minimum design ballast draft [m] at F.P.

c_2 = distribution factor (see also Fig.7.3.1)
c_2 = 0 for x/L $\leq$ 0.5

$$c_2 = \left(\frac{x}{L} - 0.5\right) / c_3 \text{ for } 0.5 < \frac{x}{L} \leq (0.5 + c_3)$$

$$c_2 = 1.0 \text{ for } (0.5 + c_3) < \frac{x}{L} \leq (0.65 + c_3)$$

$$c_2 = 0.5\left[1 + \frac{1 - x/L}{0.35 - c_3}\right] \text{ for } \frac{x}{L} > (0.65 + c_3)$$

where,

$$c_3 = 0.33 . C_b + \frac{L}{2500};$$

c_3 need not be taken greater than 0.35

x = distance of the load point from A.P. [m].

For self propelled vessels:

c_s= 1.0 for V/$\sqrt{L}$ $\geq$ 1.2

= 0.6 for V/$\sqrt{L}$ $\leq$ 0.9

For intermediate values to be obtained by linear interpolation

For non-self propelled vessels:

c_s = 0.4.

If the minimum design ballast draught T_{bf} is achieved by means of full ballast tanks in forebody resulting in internal loads on bottom shell panels, the design slamming pressure PSL on the corresponding panels may be reduced by (0.014 h) [N/mm^2], where, 'h' is the height of the ballast tank [m].

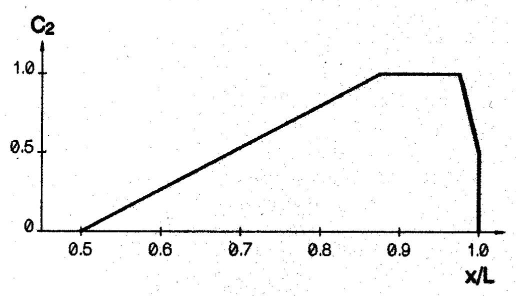


Fig.7.3.1

7.3.2 The thickness 't' of the bottom plating is not to be less than:

$t = 0.028\ f_a.f_r.s.\ \sqrt{P_{SL}}.\sqrt{k} + t_c$ [mm]

Above the region mentioned in 7.3.1 the thickness may be gradually reduced to the general requirement.

7.3.3 The section modulus 'Z' of bottom longitudinals or frames is not to be less than

$Z = 0.15\ s.\ P_{SL}\ .\ l^2\ .\ k + Z_c$ [cm^3]

The shear area, 'A_s' of the stiffeners is not to be less than

$A_s = 0.028(l - \frac{s}{1000}).s.P_{SL}.k + 0.01h\ t_c$ [cm^2]

where,

h = stiffener height [mm].

For stiffeners which are continuous at girders, the net weld area is to satisfy the following expression

$(1.7\ A_f + A_w) \geq 2\ A_s$

where,

A_f = net weld area at flange, [cm^2].

A_w = net weld area at web, [cm^2].

7.3.4 Near the shell plating, the spacing of stiffeners on the girder webs or bulkheads is not to exceed 90 times the thickness of the web or bulkhead plating.

7.3.5 The sum 'A_s' of the shear areas at the ends of the girder or girder system supporting any specified area of the bottom is not to be less than

$A_s = C_4\ S.b.P_{SL}\ .k$ [cm^2]

where,

$$C_4 = 50\left(1 - \frac{10\,S\,b}{LB}\right),$$

- but not to be taken less than 25.

S,b = The length and breadth [m] respectively of the load area supported by the girder or girder system. The design slamming pressure P_{SL} is to be calculated at the middle of the load area under consideration.

Section 8

Engine Seatings

8.1 General

8.1.1 It is recommended that the depth of the floors or double bottom in way of engine foundations be increased.

8.1.2 Sufficient fore and aft girders are to be arranged in way of the main machinery to effectively distribute its weight and to ensure adequate rigidity of the structure. The girders are generally to extend over the full length of the engine room and are to be suitably scarphed into the bottom structure beyond.

8.1.3 The scantlings of engine seatings are to be adequate to resist gravitational, thrust, torque, dynamic and vibratory forces which may be imposed on them. The recommendations given by the engine manufacturer are also to be taken into account.

8.1.4 In case of higher power oil engines or turbine installations, the seating should generally be integral with the double bottom structure. The tank top plating in way of the engine foundation plate or the turbine gear case and the thrust bearing is to be substantially increased in thickness.

8.1.5 Where the top plate of the engine seating is situated above the floors or the inner bottom, adequate transverse strength by means of brackets in line with the floors is to be ensured. In way of the recess for crankcase, brackets as large as practicable are to be fitted.

8.1.6 Lightening holes in engine foundations are to be kept as small as practicable and the edges are to be suitably reinforced.

8.2 Recommended scantlings

8.2.1 In general, the scantlings of engine girder face plate, web and floors in way of engine seatings may be calculated as given below:

where,

P = maximum power of the engine [kW]

R = rpm of engine at maximum power

l = effective length of engine foundation plate [m], required for bolting the engine to the seating.

8.2.2 For engines of P > 7000 [kW], the top plate is to be generally supported on two girders on each side.

8.2.3 The top plate area for one side of the seat is to be not less than:

A = 50+85 $\left(\frac{P}{Rl}\right)$ [cm^2] for $\left(\frac{P}{Rl}\right) \geq 2.0$

= 90+65 $\left(\frac{P}{Rl}\right)$ [cm^2] for $\left(\frac{P}{Rl}\right)$ < 2.0

8.2.4 The thickness of top plates is to be not less than:

$$t_p = \left[220\left(\frac{P}{Rl}\right) + 300\right]^{0.5} + t_o \text{ [mm]}$$

t_o = 6 where one girder is fitted on each side;

= 0 where two girders are fitted on each side.

8.2.5 The sum of the girder web thicknesses where two girders are fitted is to be not less than:

$$t_{g2} = \left[270\left(\frac{P}{Rl}\right) + 400\right]^{0.5} \text{ [mm]}$$

where single girder is fitted each side, the thickness is to be not less than:

t_{g1} = 0.55 t_{g2} [mm]

8.2.6 The thickness of floor plates below the bed plate is not to be less than:

$$t_f = \left[52\left(\frac{P}{Rl}\right) + 65\right]^{0.5} \text{ [mm]}$$

8.2.7 For high speed engines of less than 1500 [kW] and medium speed engines of less than 750 [kW] the following may be used instead of the values specified in 8.2.3 to 8.2.6 above.

Top plate area; A = 20 + 120 $\left(\frac{P}{R}\right)$ [cm^2]

Thickness of top plate; t_p = 0.1A + 14 [mm]

Girder web thickness; t_{g1} = 0.043A + 7 [mm]

Floor web thickness; t_f = 0.02A + 6 [mm].

End of Chapter

Chapter 8

Side Structure

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The scantlings and arrangement of side structure as defined in Ch.1, Sec.2 and also those of sides of the superstructures are to comply with the requirements of this Chapter.

1.2 Symbols

L, B, T, C_b, k as defined in Ch.1, Sec.2.

t_c, Z_c are corrosion additions to thickness and section modulus respectively, as given in Ch.3, Sec.2.1

f_a,f_r are correction factors for aspect ratio and curvature respectively, as defined in Ch.3, Sec.3.1.

C_w, a_o, k_s as defined in Ch.4, Sec.1.2 and Sec.3.2.

T_b = lowest design ballast draught [m]. For preliminary purposes, T_b may be taken as 0.35T [m] for cargo vessels and (2 + 0.02 L) [m] for tankers.

s = spacing of stiffeners, [mm].

l = span of stiffeners, [m].

b = spacing of girders, [m].

S = span of girders, [m].

$$f_D = \frac{Z_R}{Z_D}$$

$$f_B = \frac{Z_R}{Z_B}$$

$f_S = f_D$ for side shell area above neutral axis

$= f_B$ for side shell area below neutral axis

where,

Z_R = Rule midship section modulus [cm^3] as required by Ch.5, Sec.3.3.1.

Z_D, Z_B = Actual midship section moduli [cm^3] provided at deck and bottom respectively; calculated as per Ch.5,Sec.3.1.

$$f_z = \frac{z}{z_n}$$

where,

z_n = vertical distance [m], from the neutral axis of the hull girder to the strength deck or bottom, as relevant.

z = vertical distance [m], from the neutral axis of the hull girder to the stiffener or girder.

ϕ= roll angle [radian], as given in Ch.4, Sec.2.

Section 2

Structural Arrangement and Details

2.1 General

2.1.1 The ship's side shell may be stiffened longitudinally or vertically.

2.1.2 Where the side shell is stiffened longitudinally, the continuity of the side longitudinals within a distance of 0.15D from bottom or from strength deck is to be maintained in accordance with Ch.3, Sec.5.1.1. The web frames are to be fitted in line with the bottom transverses or plate floors.

2.1.3 The position, shape and reinforcement of sea inlets or other openings in side shell are to be in accordance with the requirements of Ch.5, Sec.5.

2.1.4 In the case of superstructures exceeding 0.15L in length and ending within 0.5L amidships, the side plating of the superstructures is to be increased by 25 per cent in way of the break. Also see Ch.11, Sec.4.1.5.

2.1.5 The thickness of the shell plating is to be increased locally by 50 per cent in way of sternframe, propeller brackets and rudder horn. For reinforcements in way of anchor pockets, hawse pipes etc. refer to Ch.15, Sec.2.1.

2.1.6 The weld connections are to comply with the requirements of Ch.17.

2.2 Sheer strake

2.2.1 The thickness of sheer strake as obtained from 4.1.5 is to be increased by 30 per cent on each side of a superstructure end bulkhead located within 0.5L amidships if the superstructure deck is a partial strength deck.

2.2.2 Where a rounded sheer strake is adopted the radius in general, is not to be less than 15 times the plate thickness.

2.2.3 Bulwarks are generally not to be welded to the top of the sheer strake within 0.6L amidships.

2.2.4 Where the sheer strake extends above the deck stringer plate, the top edge of the sheer strake is to be kept free from notches and isolated welded fittings, and is to be ground smooth with rounded edges. Drainage openings with smooth transition in the longitudinal direction may be allowed on special consideration.

2.2.5 The welding of deck fittings to rounded sheer strake within 0.6L amidships is not permitted, unless approved in each case.

Section 3

Design Loads

3.1 External sea pressure

3.1.1 The design pressure 'p' on side shell is to be taken as:

- for load points below the summer load waterline

$$p = 0.01 h_o + \left(k_s - \frac{1.5 h_o}{T}\right) C_w . R_s . 10^{-3} \ [\text{N/mm}^2]$$

- for load points above the summer load waterline

$$p = R_s \, k_s \, (C_w - 0.8 \, h_o) \, . \, 10^{-3} \ [\text{N/mm}^2]$$

where,

h_o = vertical distance [m], from the summer load waterline to the loadpoint.

'p' is not to be taken as less than 0.01 [N/mm^2].

3.2 Internal tank pressure

3.2.1 Where the side shell forms a boundary of a tank, the design pressure 'p' is to be taken as the greater of external sea pressure given by Sec.3.1 and the net internal tank pressure 'p_i' given by 3.2.2.

3.2.2 The net internal tank pressure 'pi' is to be taken as:

p_i = Internal pressure due to liquid cargo in tanks as given in Ch.4, Sec.3.3.2 less the applicable external sea pressure at lowest design ballast draught 'T_b' as given in Ch.4, Sec.3.2.4.

- For side shell above draught T_b, p_i may be taken as the greater of:

$p_i = 0.01\ h_s + p_o$ [N/mm^2], or

$= 6.7\ (h_s + \phi b)\ .10^{-3}$ [N/mm^2], or

$= 6.7\ h_p\ .\ 10^{-3}$ [N/mm^2]

where,

h_s, b = The vertical and athwartship distance [m], respectively, from the load point to the tank corner at the top of tank which is furthermost away.

h_p = vertical distance [m], from the load point to the top of air pipe.

$p_o = 0.01$ for $L \leq 20$ [m]

$= 0.024$ for $L \geq 90$ [m]

For L between 20 [m] and 90 [m] 'p_o' to be obtained by linear interpolation.

However, in mechanically propelled cargo ships of 500 GT and above and passenger ships, for tanks forming part of the watertight subdivision, (See Ch.10, Cl.4.2.1) p_0 is to be taken as not less than 0.024 [N/mm^2].

In case of tanks with stepped upper contour, the largest value of 'pi' resulting from h_s, b measurements to various tank top corners is to be considered (See Fig.3.2.2).

- For vessels of L<90 [m], for side shell below draught T_b, p_i, may be, approximated as the greater of :

$p_i = 0.01\ (h_s - h_b) + p_o$ [N/mm^2], or

$= (6.7h_p - 10h_b) \times 10^{-3}$ [N/mm^2]

where,

h_s, h_p, p_o = as given above

h_b = vertical distance [m], from the load point to the waterline corresponding to draught T_b.

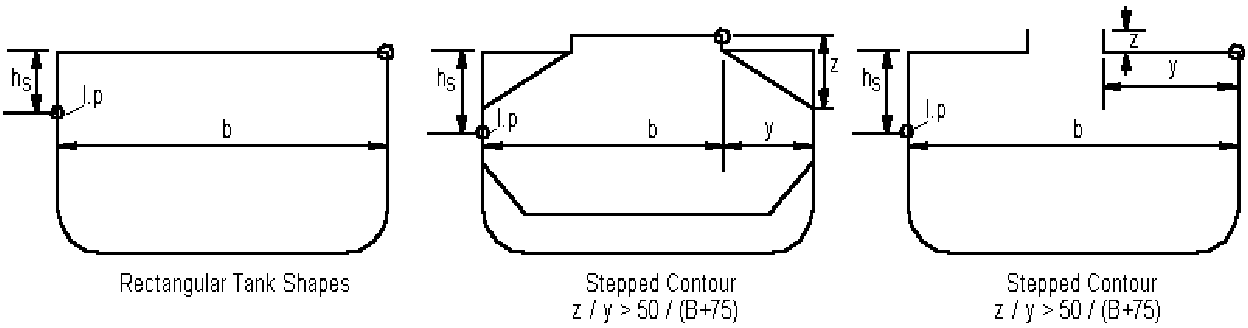


Fig.3.2.2 : Tank shapes for internal tank pressure

Section 4

Side Shell Plating and Stiffeners

4.1 Side shell plating

4.1.1 The thickness 't' of side shell is not to be less than the minimum requirement given in 4.1.4 nor less than:

$$t = f_a f_r \frac{s\sqrt{p}}{2\sqrt{\sigma}} + t_c \ [mm]$$

where,

p = applicable design pressure [N/mm^2], as given in Sec.3

σ = allowable bending stress [N/mm^2], as per Table 4.1.1.

Table 4.1.1 : σ values for side shell plating [N/mm^2]

Region	Framing system	At neutral axis	At strength deck or bottom	Between neutral axis and strength deck or bottom
0.4L amidships	Vertical	120/k	(175 - 120 f_S)/k max. 120/k	To be obtained by linear interpolation between values at neutral axis and at deck or bottom
	Longitudinal	140/k	(185 - 100 f_S)/k max. 120/k	
Within 0.05L from F.P. and 0.1L from A.P.	160/k			
Elsewhere	To be obtained by linear interpolation between allowable values at regions specified above			

4.1.2 In way of large shear forces, the side shell plating thickness is to be adequate to meet the shear strength requirements given in Ch.5, Sec.4.

4.1.3 The side shell plating is also to comply with the requirements of buckling strength given in Ch.3, Sec.6. For approximate thickness corresponding to the buckling strength requirements at deck and bottom, refer to Ch.7, Sec.4.2.3 and Ch.9, Sec.4.1.4 respectively.

4.1.4 The minimum thickness requirement of the side shell plating is given by

t = (5.0 + c.L) √k + t_c [mm]

c = 0.04 up to 4.6 [m] above the summer load waterline. For each 2.3 [m] above this level, 'c' may be reduced by 0.01 without being less than zero.

L need not be taken as more than 250 [m].

4.1.5 The breadth of the sheer strake is not to be less than (800+5L) [mm], however for ships of L < 90 [m], it need not exceed 200 D [mm].

Where the thickness of the strength deck plating is greater than that required for side plating, the sheer strake thickness is not to be less than the mean of the two values.

4.2 Side shell longitudinals

4.2.1 The section modulus 'Z' of side longitudinals is not to be less than:

$$Z = \frac{s\,p\,l^2 .10^3}{12\sigma} + Z_c \ [cm^3]$$

where,

p = applicable design pressure at midpoint of the span [N/mm^2].

σ = (215 - 135 f_S . f_z) /k, maximum 160/k [N/mm^2] for side longitudinals up to depth 'D' and within 0.4L amidships.

= 160/k [N/mm^2] within 0.1L from ends and at the level of short superstructure decks.

Between the regions specified above `σ' may be obtained by linear interpolation.

For longitudinals supported by side verticals in single deck constructions, `σ' is not to be taken as greater than 135/k [N/mm^2].

4.3 Main frames

4.3.1 Frames located between the collision bulkhead and the after peak bulkhead, connected to the floors or the double bottom and extending upto the lowest deck or shipside stringer are to be considered as main frames.

4.3.2 The section modulus 'Z' of the main frames bracketed at both ends as per 4.3.4 is not to be less than :

$$Z = \frac{s\,p\,l^2\,k}{2.4} + Z_c \;\; [cm^3] \text{ and}$$

= 6.5 √(L.k) [cm^3]

where,

p = applicable design pressure at midpoint of the span or mean of the pressures at two ends, whichever is greater, [N/mm^2].

4.3.3 The section modulus of a main frame however, is not to be less than that required for the tween deck frame above.

4.3.4 Main frame brackets are to be as follows:

length of the bracket : for upper bracket : 70 *l* [mm]

- for lower bracket : 120 *l* [mm]

section modulus at end (including bracket) - for upper bracket : 1.7 Z [cm^3]

- for lower bracket : 2.0 Z [cm^3]

where,

Z = section modulus of main frame as given in 4.3.2.

Where the free edge of the bracket exceeds 40 times the bracket thickness, the brackets are to be flanged. The flange width is to be at least 1/15 of the length of the free edge.

4.3.5 Brackets at ends of the main frame may be omitted provided the frame is carried through the supporting members and the section modulus obtained as per 4.3.2 is increased by 75 per cent.

4.4 Tween deck frames, super structure frames

4.4.1 Tween deck frames and superstructure frames located between the collision bulkhead and the after peak bulkhead are to have section modulus 'Z' not less than:

$$Z = \frac{s\,p\,l^2\,k}{1.6} + Z_c \;\; [cm^3] \text{ and}$$

= 4.0 √(L.k) [cm^3]

where,

p = applicable design pressure as given in Sec.3.

4.4.2 The lower end of the tween deck and superstructure frames is to be connected to the bracket or frame below or else it is to be bracketed above the deck. The upper end is to be bracketed to the deck beam or longitudinal.

4.5 Peak frames

4.5.1 Vertical peak frames forward of the collision bulkhead and aft of the after peak bulkhead are to have section modulus 'Z' not less than

$$Z = \frac{s\,p\,l^2\,k}{1.6} + Z_c \;\; [cm^3] \text{ and}$$

= 6.5 √(L.k) [cm^3]

where,

p = applicable design pressure [N/mm^2], as given in Sec.3.

4.5.2 Peak frames are to be bracketed at top and bottom and in way of side stringers, the connection is to provide adequate shear strength.

4.6 Tripping brackets

4.6.1 Where the span of frames exceeds 5 [m] and/or the flange width is less than 1/20 of the span 'l', tripping brackets are to be fitted at the middle of the span.

4.6.2 Forward of 0.15L from F.P., the tripping brackets are to be fitted on frames as shown in Fig.4.6.2. The spacing between tripping brackets is not to exceed 2.5 [m] vertically.

4.6.3 The thickness of tripping brackets is to be same as that of the frame web, however it need not exceed 10 [mm].

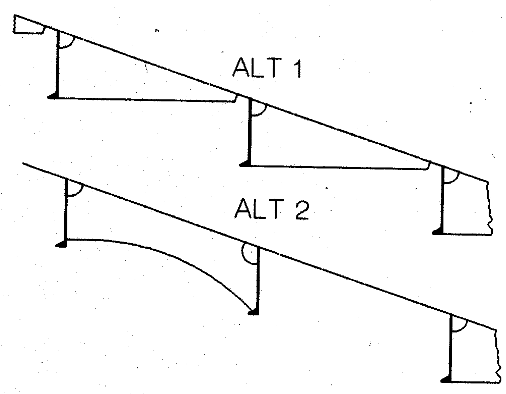


Fig. 4.6.2 : Tripping brackets

Section 5

Girders

5.1 General

5.1.1 Web frames are to be fitted in way of hatch end beams and deck transverses.

5.1.2 In the engine and boiler room, web frames are to be fitted at the forward and aft end of the engine and every 5th frame in general. In addition, where the engine room is situated aft and the span of the frames up to the lowest deck exceeds 6.5 [m], a side stringer is to be provided. The section modulus `Z' of the web frames and side stringers is to be obtained as per 5.1.5 taking 'b' as the mean of the web frame or stringer spacings respectively, on either side. The depth of the webs and stringers are not to be less than 2.5 times the depth of the ordinary frames.

Adequate deep beams are to be provided in line with the web frames.

5.1.3 In peak spaces, side stringers supporting vertical peak frames are normally to be fitted at every 2.6 [m]. The section modulus `Z' of the stringers is to be obtained as per 5.1.5. The stringers are to be supported by web frames.

Alternatively in fore peak spaces, unflanged stringers supported by panting beams at alternate frames may be provided. The scantlings of these stringers is not to be less than the following :

- width = 75 $\sqrt{L}$ [mm]

- thickness = 6 + 0.025L [mm]

The panting beams are to comply with buckling strength requirement given in Ch.3, Sec.6 and are to be bracketed to the frames. Intermediate frames are to be bracketed to the stringers.

5.1.4 The scantlings of simple girders and web frames supporting frames and longitudinals are to be in accordance with 5.1.5. The scantlings of webs supporting fully effective side stringers are to based on point loadings and 'σ' values given in 5.1.5. The scantlings of the complex girder system are to be based on a direct stress analysis. The buckling strength of the cross ties, where fitted, is to comply with the requirements given in Ch.3, Sec.6.

5.1.5 The section modulus 'Z' of simple girders and web frames is not to be less than :

$$Z = \frac{b\,p\,S^2 .10^6}{m\sigma} + Z_c \ [cm^3]$$

where,

p = applicable design pressure [N/mm^2], as given in Sec 3.

m = 12 for continuous longitudinal girders with end attachments in accordance with Ch.3, Sec.5.

= 10 for other girders with end attachments in accordance with Ch.3, Sec.5.

σ = (190 - 135 f_S . f_z)/k, max 160/k [N/mm^2], for continuous longitudinal girders within 0.4L amidships.

= 160/k [N/mm^2] for longitudinal girders within 0.1L from ends and for web frames in general.

Between the regions specified above, σ may be obtained by linear interpolation.

5.1.6 The effective cross sectional area 'A' of the girder web at ends obtained as per Ch.3, Sec.4.4 is not to be less than

A = 60 Sbpk + 0.01 h t_c [cm^2] for stringers and upper ends of the web frames.

= 80 Sbpk + 0.01 h t_c [cm^2] for lower ends of the web frames.

where,

h = girder height [mm].

5.1.7 The girders are to be satisfactorily stiffened against buckling in accordance with the requirements given in Ch.3, Sec.6. Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.

End of Chapter

Chapter 9

Deck Structure

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The scantlings and arrangement of deck structure as defined in Ch.1, Sec.2 are to comply with the requirements given in this Chapter.

1.2 Symbols

L,B,T,C_b,k as defined in Ch.1, Sec.2.

t_c,Z_c = corrosion additions to thickness and section modulus respectively as given in Ch.3, Sec.2.1.

f_a, the correction factor for aspect ratio as defined in Ch.3, Sec.3.1.

C_w, a_o, k_v and k_s as defined in Ch.4, Sec.1.2, Sec.2.3 and Sec.3.2.

s = spacing of stiffeners, [mm]

l = span of stiffeners, [m]

b = spacing of girders, [m]

S = span of girders, [m]

$$f_D = \frac{Z_R}{Z_D}$$

where,

Z_R = Rule midship section modulus [cm3], as required by Ch.5, Sec.3.3.1.

Z_D = actual midship section modulus [cm3], provided at deck calculated as per Ch.5, Sec.3.1.

$$f_z = \frac{z}{z_n}$$

where,

z_n = vertical distance [m], from the neutral axis of the hull girder to the strength deck, in general. For ships with continuous trunks refer to Ch.5, Sec.3.1.3.

z = vertical distance [m], from the neutral axis of the hull girder to the deck under consideration or to the free flange of the deck longitudinal or girder as relevant.

ϕ= roll angle [radians], as given in Ch.4, Sec.2.

Section 2

Structural Arrangement and Details

2.1 General

2.1.1 In tankers, the deck is normally to be stiffened longitudinally in the cargo tank region, however, where L does not exceed 75 [m], consideration may be given to transversely stiffened decks.

2.1.2 In dry cargo ships of L>150 [m], the strength deck outside the line of hatchway openings is normally to be longitudinally stiffened.

2.1.3 The continuity of the deck longitudinals is to be maintained in accordance with Ch.3, Sec.5.1.1.

2.1.4 The deck within the line of hatchway openings is preferably to be stiffened transversely or alternatively the arrangements are to provide adequate transverse buckling strength. Where the deck outside the line of hatchway openings is framed longitudinally, the transverse beams or buckling stiffeners between the hatchways are to extend at least upto the second longitudinal from the hatch side or equivalent.

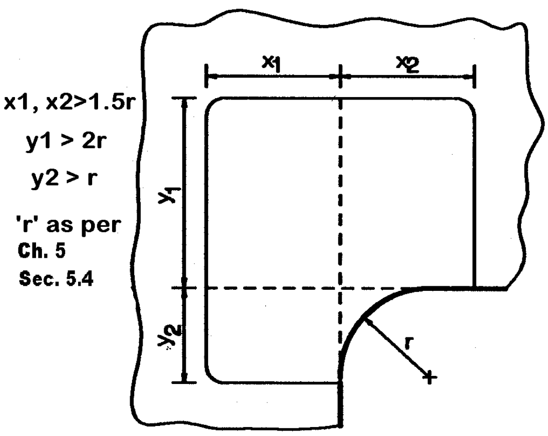


Fig.2.1.6 : Extent of insert plate

2.1.5 In ships with large hatch openings, the effective cross-sectional area of the deck between the hatchways is to be sufficient to withstand the transverse load acting on the ship's sides. Bending and shear stresses arising as a result of loading on the transverse bulkhead supported by the deck area and also as a result of displacements caused by torsion of the hull girder, are to be considered and the necessary reinforcements are to be provided.

The following items may be included in the effective cross-sectional area of the decks; corrosion additions, if any, are to be deducted:

- deck plating
- transverse beams and deck transverses
- hatch end beams (upon special conside-ration)
- cross section of stool at top of transverse bulkhead
- cross section of transverse bulkhead (if plane or horizontally corrugated) down to base of top wing tank or to 0.15 D from deck.

The compressive stress in the above mentioned items is not to be greater than 120/k [N/mm^2], nor 80 per cent of the critical buckling stress found in accordance with Ch.3, Sec.6.

2.1.6 Hatchway corners are to be of streamlined, elliptical or circular shape as given in Ch.5, Sec.5.4. Where shapes other than the streamlined shape or equivalent are adopted, insert plates are to be fitted at the hatch corners in strength deck. The insert plates are to be 25 per cent thicker than the deck plating outside the line of hatchways and are to extend as shown in

Fig.2.1.6. The butts of insert plates are to be well clear of those in coaming.

2.1.7 The weld connections are to comply with the requirements of Ch.17.

Section 3

Design Loads

3.1 Weather deck

3.1.1 The design pressure 'p' on decks or parts of decks which are exposed to the wash of the sea is to be taken as:

$p = R_s\, k_s\, (C_w - 0.8\, h_o)\, .\, 10^{-3}$ [N/mm^2]

where,

h_o = vertical distance [m], from the summer load waterline to the deck.

'p' is not to be taken as less than

- 0.015 [N/mm^2] for weather decks forward of 0.15L from F.P. or forward of deckhouse front whichever is the foremost position
- 0.005 [N/mm^2] for weather decks elsewhere.

3.1.2 For weather decks except those forming crowns of tanks in dry cargo ships, the design pressure 'p' is to be taken as the greater of that given by 3.1.1 and 3.2.1, taking deck load `q' as not less than:

q = 1.0 [t/m^2] for L $\leq$ 100 [m]

= 1.3 [t/m^2] on superstructure deck for L $\geq$ 150 [m]

= 1.75 [t/m^2] on freeboard deck for L $\geq$ 150 [m]

For L between 100 [m] and 150 [m], 'q' is to be obtained by linear interpolation.

Where the design stowage height of weather deck cargo is smaller than 2.3 [m], an appropriate combination of the two loads is to be considered.

3.1.3 For weather decks forming crowns of tanks, the design pressure 'p' is to be taken as the greater of that given by 3.1.1 and 3.3.2.

3.2 Tween decks, platform decks and accommodation decks

3.2.1 The design pressure 'p' on tween decks, platform decks and accommodation decks is to be taken as :

$$p = q\left(1 + \frac{0.5\, k_v\, a_o}{C_b}\right).10^{-2}\ \text{[N/mm}^2\text{]}$$

where,

q = deck cargo load [t/m^2].

= ρ.H [t/m^2] for tween decks

= 1.6 [t/m^2] for platform decks in machinery spaces

= 0.35 [t/m^2] for accommodation decks.

H = tween deck height or height measured upto the top of hatchway coaming, [m].

ρ = cargo density [t/m^3], not to be taken as less than 0.7 [t/m^3] except as specified in Ch.4, Sec.3.4.1.

3.2.2 For decks forming crowns of tanks the design pressure 'p' is to be taken as the greater of that given by 3.2.1 and 3.3.2.

3.3 Decks forming tank boundaries

3.3.1 The design pressure 'p' for decks forming the bottom of a tank may be taken as the greater of the following:

$p = 6.7\, h_p\, .\, 10^{-3}$ [N/mm^2] or

$= 0.01\, h_s + p_o$ [N/mm^2]

where,

h_p = vertical distance [m], from the deck to the top of air pipe

h_s = vertical distance [m], from the deck to the top of the tank

p_o = 0.01 [N/mm^2] for L $\leq$ 20 [m]

= 0.024 [N/mm^2] for L $\geq$ 90 [m]

For L between 20 [m] and 90 [m], 'po' is to be obtained by linear interpolation.

However, in mechanically propelled cargo ships of 500 GT and above and passenger ships, for tanks forming part of the watertight subdivision, (See Ch.10, Cl.4.2.1) p_0 is to be taken as not less than 0.024 [N/mm^2].

3.3.2 The design pressure 'p' for decks forming the crown of a tank may be taken as the greater of the following:

p = 6.7 h_p . 10^{-3} [N/mm^2] or

= 6.7 (h_s + ϕb) . 10^{-3} [N/mm^2]

= 0.01 h_s + p_o [N/mm^2]

where, h_p and p_o are as given in 3.3.1.

h_s, b = the vertical and athwartship distance, [m] respectively, from the point of deck under consideration to the tank corner at the top of the tank which is furthermost away.

In case of tanks with stepped upper contour, the largest value of 'p' resulting from the h_s, b, measurements to various tank top corners is to be considered.

Section 4

Deck Platings and Stiffeners

4.1 Deck platings

4.1.1 The thickness of the strength deck plating outside the line of hatchway openings is to be adequate to give the necessary hull section modulus and moment of inertia required by Ch.5.

4.1.2 The thickness 't' of deck platings is not to be less than the minimum requirement given in 4.1.3 nor less than:

$$t = \frac{f_a \cdot s\sqrt{p}}{2\sqrt{\sigma}} + t_c \ \text{[mm]}$$

where,

p = applicable design pressure [N/mm^2] as given in Sec.3.

σ = allowable bending stress [N/mm^2] as per Table 4.1.2.

4.1.3 The minimum thickness requirement of the deck platings is given by:

t = (t_o+0.02L) $\sqrt{k}$ + t_c [mm]

L need not be taken as more than 250 [m].

where,

t_o = 6 for strength decks and forecastle decks

= 5.5 for tween decks and first tier of erections

= 5.0 for other decks.

Where deck coverings in accordance with Ch.2, Sec.4 are provided, the deck thickness may be reduced by 10 per cent without being less than 5.0 [mm].

Table 4.1.2 : σ values for deck plating [N/mm²]				
Region	**Framing system**	**Strength deck**	**Other continuous decks**	**Short decks**
0.4L amidships	Transverse	(175 - 120 f_D)/k max. 120/k	(175 - 120 f_D.f_z)/k max. 160/k	160/k
	Longitudinal	(185 - 100 f_D)/k max. 120/k	(185 - 100 f_D.f_z)/k max. 160/k	160/k
Within 0.1L from ends	160/k			
Elsewhere	To be obtained by linear interpolation between allowable values at regions specified above			

4.1.4 The strength deck plating outside the line of hatchways is also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

For ships of L > 90 [m], thickness 't' of the strength deck plating within 0.4L amidships, corresponding to the buckling strength requirement may be approximated as:

$$t = \frac{0.009\,s\sqrt{k}}{\sqrt{(1-0.75\,f_D)}} + t_c \ \text{[mm]}$$

- for longitudinally stiffened decks and

$$\frac{0.0164\,s\sqrt{k}}{[1+(s/1000l)^2]\ \sqrt{(1-0.75\,f_D)}} + t_c \ \text{[mm]}$$

- for transversely stiffened decks.

4.1.5 In way of ends of bridges, poops and forecastles, the thickness of the strength deck stringer strake is to be increased by 20 per cent over four frame spaces fore and also aft of the end bulkheads.

4.2 Deck stiffeners

4.2.1The section modulus 'Z' of deck longitudinals is not to be less than:

$$Z = \frac{s\,p\,l^2\,.10^3}{12\sigma} + Z_c \ [cm^3]$$

where,

p = applicable design pressure [N/mm²] as given in Sec.3.

σ = (215-135f_D.f_z)/k, max. 160/k [N/mm²] for strength deck and decks of long superstructures/deckhouses within 0.4L amidships.

= (225-135f_D.f_z)/k, max. 160/k [N/mm²] for continuous decks below strength deck within 0.4L amidships.

= 160/k [N/mm²] within 0.1L from ends and for short decks.

Elsewhere, σ may be obtained by linear interpolation.

The longitudinals are also to comply with the requirements of buckling strength given in Ch.3, Sec.6.

4.2.2 The section modulus 'Z' of transverse beams is not to be less than

$$Z = \frac{s\,p\,l^2}{1.6} + Z_c \ [cm^3]$$

where,

p = applicable design pressure [N/mm²] as given in Sec.3.

Section 5

Deck Girders and Pillars

5.1 Girders

5.1.1 Deck girders and transverses are to be arranged in line with vertical members of scantlings sufficient to provide adequate support.

5.1.2 The scantlings of simple girders and transverses are to be in accordance with 5.1.3. The scantlings of a complex girder system are to be based on a direct stress analysis.

5.1.3 The section modulus 'Z' of deck girders is not to be less than:

$$Z = \frac{b\,p\,S^2\,.10^6}{m\sigma} + Z_c \ [cm^3]$$

where,

p = applicable design pressure [N/mm^2] as given in Sec.3.

m = 12 for continuous longitudinal girders with end attachments in accordance with Ch.3, Sec.5.

= 10 for other girders with end attachments in accordance with Ch.3, Sec.5.

σ = (190-135f_D.f_z)/k, max. 160/k [N/mm^2] for continuous longitudinal girders within 0.4L amidships.

= 160/k [N/mm^2] for longitudinal girders within 0.1L from ends and for transverse girders in general.

Elsewhere, `σ' may be obtained by linear interpolation.

5.1.4 The effective cross sectional area 'A' of the girder web at ends obtained as per Ch.3, Sec.4.4 is not to be less than:

A = 70.S.b.p k + 0.01h t_c [cm^2]

where,

h = girder height [mm].

5.1.5 The girders are to be satisfactorily stiffened against buckling in accordance with the requirements given in Ch.3, Sec.6. Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.

5.2 Cantilevers

5.2.1 The scantlings of cantilever beams and supportings frame will be specially considered.

5.3 Pillars

5.3.1 The scantlings of the pillars are to be in accordance with the requirements of Ch.3, Sec.6. Axial load, if any, from pillars above is to be added to the load from deck girders.

The minimum wall thickness 't' [mm], of the tubular pillars is not to be less than:

t = 4.5 + 0.015 d for d < 300 [mm]

= 0.03d for d $\geq$ 300 [mm]

where,

d = diameter of the pillar [mm].

5.3.2 Pillars are to be fitted in the same vertical line wherever possible, and arrangements are to be made to effectively distribute the load at the heads and heels. Where pillars support eccentric loads, they are to be strengthened for the additional bending moments imposed upon them. Doubling or insert plates are generally to be fitted at the head and heel of hollow pillars.

5.3.3 The pillars are to have a bearing fit and are to be attached to the head and heel plates by continuous welding.

5.3.4 Where the heels of hold pillars are not directly above the intersection of plate floors and girders, partial floors and intercostal girders are to be fitted as necessary to support the pillars. Lightening holes or manholes are not to be cut in the floors and girders below the heels of pillars.

5.3.5 Inside tanks, hollow pillars are not to be used and strengthening at the heads and heels of pillars is not to be obtained by means of doubling plates. Where hydrostatic pressure may give rise to tensile stresses in the pillars, their sectional area 'A' is not to be less than

$A = 70.A_L.p$ [cm^2]

where,

p = design pressure as given in Sec.3, causing the tensile stress in pillar

A_L = load area of deck [m^2], being supported by the pillar.

Section 6

Decks for Wheel Loading

6.1 General

6.1.1 Where it is proposed either to stow wheeled vehicles on the deck or to use wheeled vehicles for cargo handling, the requirements of this section are to be complied with in addition to those given in the preceding sections.

6.1.2 The requirements given below are based on the assumption that the considered element (Deck plating and/or stiffener) is subjected to one load area only, and that the element is continuous over several evenly spaced supports. The requirements for other loads and/or boundary conditions will be specially considered.

A "load area" is the tyre print area of individual wheels; for closely spaced wheels it may be taken as the enveloped area of the wheel group.

6.1.3 The details of wheel loadings are to be forwarded by the shipbuilder. These details are to include the proposed arrangement and dimensions of tyre prints, axle and wheel spacings, maximum axle load and tyre pressure.

6.2 Wheel loads

6.2.1 The pressure 'p' from the wheels on deck is to be taken as:

$$p = \frac{W}{n.a.b}.(9.81 + 0.5\,a_v).10^3 \ \ [\text{N/mm}^2]$$

where,

W = maximum axle load, [t]. For fork lift trucks, the total weight is to be taken as the axle load.

n = number of "load areas" per axle

a = extent [mm], of the load area parallel to the stiffener (see Fig.6.2.1)

b = extent [mm], of the load area perpendicular to the stiffener (see Fig.6.2.1)

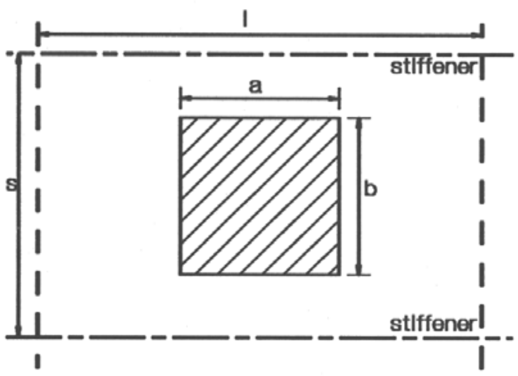


Fig. 6.2.1 : Plate panel and load

a_v = vertical acceleration [m/s^2], as follows:

$$= \frac{9.81.k_v\,a_o}{C_b} \ [\text{m/s}^2]$$

- for stowed vehicles, in sea going condition

$$= \frac{6}{\sqrt{W}} \ \ [\text{m/s}^2]$$

for cargo handling vehicles in harbour condition

6.3 Deck plating

6.3.1 The thickness 't' of deck plating subjected to wheel loadings is not to be less than;

$$t = c_1\,f_a\,\sqrt{\frac{c_2\,b\,s\,p\,k}{m}} + t_c \ \ [\text{mm}]$$

where,

f_a = (1.1 - 0.25 s/l) for s ≤ l, however need not be taken as greater than 1.0

a,b,s,l = deck panel dimensions [mm] (see Fig.6.2.1)

c_1 = 0.137 in general for seagoing conditions

= 0.127 in general for harbour conditions

= As per Table 6.3.1 for upper deck within 0.4L amidships.

Table 6.3.1 : c_1 values for upper deck plating within 0.4Lamidships

Framing system	c_1-seagoing conditions	c_1-harbour conditions
Longitudinal	0.145	0.130
Transverse	0.180	0.145

For upper deck plating between 0.4L amidships and 0.1L from ends, c_1 is to be varied linearly.

$$c_2 = 1.3 - \frac{4.2}{(a/s + 1.8)^2},$$

however, need not be taken as greater than 1.0

$$m = \frac{38}{(b/s)^2 - 4.7\,(b/s) + 6.5} \text{ for } b \le s.$$

6.4 Deck stiffeners

6.4.1 The section modulus 'Z' of deck beams and longitudinals subjected to wheel loadings is not to be less than:

$$Z = \frac{c_3 . a . b . l . p}{m \sigma} 10^{-3} + Z_c \quad [cm^3]$$

where,

c_3 = (1.15 - 0.25 b/s) for $b \le s$, however need not be taken as greater than 1.0

$$m = \frac{r}{(a/l)^2 - 4.7\, a/l + 6.5}$$

r = 29 for continuous stiffeners supported at girders

= 38 when the continuous stiffeners can be considered as rigidly supported at girders against rotation.

σ = 160/k [N/mm^2] in general, for seagoing conditions

= 180/k [N/mm^2] in general, for harbour conditions

= As per Table 6.4.1 for deck longitudinals within 0.4L amidships, but not exceeding the above general values.

For deck longitudinals between 0.4L amidships and 0.1L from ends is to be varied linearly.

Table 6.4.1 : σ Values for longitudinals within 0.4L amidships

Condition	σ [N/mm^2]
Seagoing	$(215\text{-}135 f_D . f_z)/k$
Harbour	$(225\text{-}85\ f_D . f_z)/k$

6.5 Deck girders

6.5.1 The scantlings of girders will be specially considered based on the most severe condition of moving or stowed vehicles. Also see 6.1.3.

End of Chapter

Chapter 10

Bulkheads

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The requirements of this chapter cover the arrangement and scantlings of watertight and deep tank bulkheads.

1.1.2 The requirements also cover the non-watertight bulkheads and shaft tunnels.

1.2 Statutory requirements

1.2.1 Where applicable, the number and disposition of bulkheads are to be arranged to meet the requirements for subdivision, floodability and damage stability in accordance with the requirements of the National Authority of the country in which the ship is registered.

1.3 Definitions and Symbols

1.3.1 *Bulkhead Deck*: In a passenger ship, the uppermost deck at any point in the length of the ship to which the main bulkheads and the ship's shell are carried watertight and the lowermost deck from which passenger and crew evacuation will not be impeded by water in any stage of flooding for damage cases defined in SOLAS Ch II-1 Reg.8 and in SOLAS Ch II-1 Part B-2. The bulkhead deck may be a stepped deck.
In a cargo ship the freeboard deck may be taken as the bulkhead deck.

L, B, T, C_b, k as defined in Ch.1, Sec.2.

t_c, Z_c are corrosion additions to thickness and section modulus respectively as given in Ch.3, Sec.2.1

a_o, k_v are as defined in Ch.4.

s = spacing of stiffeners [mm]

l = span of stiffeners [m]

b = spacing of girders [m]

S = span of girders [m]

$$f_D = \frac{Z_R}{Z_D}$$

$$f_B = \frac{Z_R}{Z_B}$$

where,

Z_R = Rule midship section modulus [cm^3] as required by Ch.5, Sec.3.3.3.

Z_D, Z_B = Actual midship section moduli in [cm^3] provided at deck and bottom respectively calculated as per Ch.5, Sec.3.1.

$f_s = f_D$ for side shell area above neutral axis

$f_s = f_B$ for side shell area below neutral axis

$$f_z = \frac{z}{z_n}$$

where,

z_n = vertical distance [m] from the neutral axis of the hull girder to the strength deck or bottom as relevant.

z = vertical distance [m] from the neutral axis of the hull girder to the stiffener or girder.

Section 2

Subdivision and Arrangement

2.1 Number of bulkheads

2.1.1 The following transverse watertight bulkheads are to be fitted in all ships:

- A collision bulkhead;
- An afterpeak bulkhead;
- A bulkhead at each end of the machinery space.

For ships without longitudinal bulkheads in the cargo region, additional transverse watertight bulkheads are to be fitted so that the total number of bulkheads is not less than that given in Table 2.1.1.

Table 2.1.1: Total no. of bulkheads

	Engine Room Location	
Ship length [m]	**Aft***	**Elsewhere**
$L \leq 65$	3	4
$65 < L \leq 85$	4	4
$85 < L \leq 105$	5	5
$105 < L \leq 115$	5	6
$115 < L \leq 125$	6	6
$125 < L \leq 145$	6	7
$145 < L \leq 165$	7	8
$165 < L \leq 190$	8	9
$L > 190$	Specially considered	
* With aftpeak bulkhead forming after boundary of machinery space		

2.1.2 The ordinary transverse watertight bulkheads in the holds should be spaced at reasonably uniform intervals. Where non-uniform spacing is unavoidable and the length of a hold is unusually large, the transverse strength of the ship is to be maintained by providing additional web frames, increased framing etc.

2.1.3 Proposals to dispense with one or more of these bulkheads will be considered, subject to suitable structural compensation, in case they interfere with the requirements of a special trade.

2.2 Position of collision bulkhead

2.2.1 The distance X_c from the forward perpendicular to the collision bulkhead is to be between the following limits:

$X_{c,min} = 0.05L_L - X_R$ [m] for $L < 200$ [m].

$= 10 - X_R$ [m] for $L \geq 200$ [m].

$X_{c,max} = 0.05\ L_L - X_R + 3$ [m] for $L < 100$ [m].

$= 0.08\ L_L - X_R$ [m] for $L \geq 100$ [m].

For ships with ordinary bow shape;

$X_R = 0$

For ships having any part of the underwater body extending for'd of the forward perpendicular e.g., a bulbous bow;

X_R = the least of :
- G/2;
- 0.015 L_L and
- 3.0 [m].

where,

G = the distance from forward perpendicular to the forward end of the protruded part [m]

L_L = the load line length of the vessel [m], as per International Load Line Convention (see Ch.1).

2.2.2 Consideration will however be given to proposals for the collision bulkhead positioned aft of the limits given in 2.2.1, provided that the application is accompanied by calculations showing that with the ship fully loaded to summer draught on even keel, flooding of space forward of the collision bulkhead will not result in any part of the bulkhead deck / freeboard deck becoming submerged, nor result in any unacceptable loss of stability.

2.2.3 Any recesses or steps in collision bulkheads are to fall within the limits of bulkhead positions given in 2.2.1. Where the bulkhead is extended above the bulkhead deck / freeboard deck, the extension need only be to weathertight standards. If a step occurs at that deck, the deck also need be to only weathertight standards in way of the step unless the step forms the crown of a tank.

2.2.4 In ships fitted with visor or bow doors, in which a sloping loading ramp forms part of the collision bulkhead above the bulkhead deck / freeboard deck, that part of the ramp which is more than 2.3 [m]. above the bulkhead deck / freeboard deck may extend forward of the minimum limit specified in 2.2.1. Such a ramp is to be weathertight over its complete length.

2.3 After peak bulkhead and shaft tunnel

2.3.1 All ships are to have an after peak bulkhead generally enclosing the sterntube and rudder trunk in a watertight compartment. In twin screw ships where the bossing ends forward of the after peak bulkhead, the sterntubes are to be enclosed in suitable watertight spaces inside or aft of the shaft tunnels.

2.3.2 In passenger ships, the stern gland is to be situated in a watertight shaft tunnel or other watertight space separate from the stern tube compartment and of such volume that if flooded by leakage through the stern gland, the bulkhead deck will not be immersed.
In cargo ships, where the inboard end of the stern tube extends into the engine room, provision of an approved watertight/ oil tight gland system for sealing of the inboard end of the stern tube at the aft peak/engine room watertight bulkhead is considered sufficient to minimize danger of water penetrating into the ship in case of damage to stern tube arrangements.
(See also Pt.4, Ch.4, Sec. 6.16).

2.3.3 In ships with engines situated amidships, a watertight shaft tunnel is to be arranged. Openings in the forward end of shaft tunnels are to be fitted with watertight sliding doors capable of being operated from a position above the load water line.

2.4 Height of bulkheads

2.4.1 The watertight bulkheads are in general to extend to the bulkhead deck / freeboard deck. The afterpeak bulkhead however, may terminate at the first deck above the load waterline, provided that this deck is made watertight to the stern or to a watertight transom floor provided the degree of safety of the ship as regards the subdivision is not thereby diminished.

2.4.2 The collision bulkhead is normally to extend to the bulkhead deck / freeboard deck or, in the case of ships with combined bridge and forecastle or a long superstructure that includes a forecastle, to the superstructure deck. However, if a ship is fitted with more than one complete superstructure deck, the collision bulkhead may be terminated at the deck next above the bulkhead deck / freeboard deck. Where the collision bulkhead extends above the bulkhead deck / freeboard deck, the extension need only be to weathertight standard.

2.4.3 In passenger ships of restricted draught and all ships of unusual design, the height of bulkheads will be specially considered.

2.5 Openings in watertight bulkheads and closing appliances - General

2.5.1 Openings may be accepted in watertight bulkheads except in that part of collision bulkhead which is situated below the bulkhead deck / freeboard deck. The number of openings in watertight subdivisions is to be kept to a minimum compatible with the design and proper working of the ship. Where penetrations of watertight bulkheads are necessary for access, piping, ventilation, electrical cables, etc., arrangements are to be made to maintain the watertight integrity. Relaxation in the watertightness of openings above the bulkhead deck / freeboard deck may be considered provided it is demonstrated that any progressive flooding can be easily controlled and that the safety of the ship is not impaired.

2.5.2 Openings in the collision bulkhead above the bulkhead deck / freeboard deck are to have weathertight doors or an equivalent arrangement.

2.5.3 Doors, manholes, permanent access openings or ventilation ducts are not to be cut in the collision bulkhead below the freeboard deck.

2.5.4 Where watertight bulkhead stiffeners are cut in way of watertight doors in the lower part of the bulkhead, the opening is to be suitably framed and reinforced. Where stiffeners are not cut but the spacing between the stiffeners is increased on account of watertight doors, the stiffeners at the sides of the doorways are to be increased in depth and strength so that the efficiency is at least equal to that of the unpierced bulkhead, without taking the stiffeners of the door-frame into consideration.

2.6 Doors in watertight bulkheads for ships where subdivision / damage stability requirements are applicable

2.6.1 The requirements in 2.6.1 to 2.6.16 apply to doors located in way of the internal watertight subdivision boundaries and the external watertight boundaries necessary to ensure compliance with the relevant subdivision and damage stability regulations.

These requirements do not apply to doors located in external boundaries above equilibrium or intermediate waterplanes.

2.6.2 Definitions

For the purpose of the requirements in this subsection (2.6) the following definitions apply:

a) *Watertight* : Capable of preventing the passage of water in any direction under a design head. The design head for any part of a structure shall be determined by reference to its location relative to the bulkhead deck or freeboard deck, as applicable, or to the most unfavourable equilibrium / intermediate waterplane, in accordance with the applicable subdivision and damage stability regulations, whichever is the greater. A watertight door is thus one that will maintain the watertight integrity of the subdivision bulkhead in which it is located.

b) *Equilibrium Waterplane* : The waterplane in still water when, taking account of flooding due to an assumed damage, the weight and buoyancy forces acting on a vessel are in balance. This relates to the final condition when no further flooding takes place or after cross flooding is completed.

c) *Intermediate Waterplane* : The waterplane in still water, which represents the instantaneous floating position of a vessel at some intermediate stage between commencement and completion of flooding when, taking account of the assumed instantaneous state of flooding, the weight and buoyancy forces acting on a vessel are in balance.

d) *Sliding Door or Rolling Door* : A door having a horizontal or vertical motion generally parallel to the plane of the door.

e) *Hinged Door* : A door having a pivoting motion about one vertical or horizontal edge.

2.6.3 Structural design

Doors are to be of approved design and are to be of a strength equivalent to that of the subdivision bulkheads in which they are fitted.

2.6.4 Operation mode, location and outfitting

Doors are to be fitted in accordance with all requirements regarding their operation mode, location and outfitting, i.e. provision of controls, means of indication etc. as shown in Table 2.6.4. For passenger ships, in addition to the requirements given in the Table 2.6.4 the watertight doors and their controls are to be located in compliance with the following:

a) The door is to be located inboard of the damage zone B/5 on P&S as per SOLAS II-1 Reg.13.7.

b) The door controls including hydraulic piping and electric cables are to be kept as close as practicable to the bulkhead in which the doors are fitted in order to minimize the likelihood of them being involved in any damage to the ship. The positioning of doors and controls is to be such that if the ship sustains damage within damage zone B/5 as mentioned above, the operation of the doors clear of the damaged portion of the ship is not impaired.

2.6.5 Frequency of use whilst at sea

a) Normally closed
Kept closed at sea but may be used if authorised. To be closed again after use.

b) Permanently closed

The time of opening such doors in port and of closing them before the ship leaves port shall be entered in the log-book. Should such doors be accessible during the voyage, they shall be fitted with a device to prevent unauthorised opening.

c) Normally open
May be left open provided it is always ready to be immediately closed.

d) Used
In regular use, may be left open provided it is ready to be immediately closed.

Table 2.6.4 : Internal doors in watertight bulkheads in cargo ships and passenger ships

Position relative to equilibrium or intermediate waterplane	1. Frequency of use whilst at sea	2. Type	3. Remote control[6]	4. Indication locally and on bridge[6]	5. Audible alarm[6]	6. Notice	7. Comments	8. Regulation
I. Passenger Ships								
A. At or below	Norm. Closed	POS	Yes	Yes	Yes	No	Certain doors may be left open, see SOLAS II-1/22.4	SOLAS II-1/ 13; SOLAS II-1/22.1, 2, 3 and 4
	Perm. Closed	S, H	No	No	No	Yes	See Notes 1+4	SOLAS II-1/13.9 & 2
B. Above	Norm. Open	POS, POH	Yes	Yes	Yes	No		SOLAS II-1/22.4 SOLAS II-1/ 17.1 MSC/Circ.541
	Norm. Closed	S, H	No	Yes	No	Yes	See Note 2	
		S, H	No	Yes	No	Yes	Doors giving access to Ro-Ro Deck	SOLAS II-1/17.1 SOLAS II-1/23
II. Cargo Ships								
A. At or below	Used	POS	Yes	Yes	Yes	No		SOLAS II-1/13.2
	Norm. Closed	S, H	No	Yes	No	Yes	See Notes 2+3+ 5	SOLAS II-1/13.1 SOLAS II-1/22.3,4
	Perm. Closed	S, H	No	No	No	Yes	See Notes 1+4	SOLAS II-1/13.1.4 SOLAS II-1/15-1 SOLAS II-1/22.6
B. Above	Used	POS	Yes	Yes	Yes	No		SOLAS II-1/13-1.2
	Norm. Closed	S, H	No	Yes	No	Yes	See notes 2+5	SOLAS II-1/ 13-1.3 SOLAS II-1/22-10

Notes:

1. Doors in watertight bulkheads subdividing cargo spaces.
2. If hinged, this door shall be of quick acting or single action type.
3. "ICLL66+A320" or "1988 Protocol to ICLL66", SOLAS, MARPOL, IGC and IBC - Codes require remotely operated watertight doors to be sliding doors.
4. The time of opening such doors in port and closing them before the ship leaves port shall be entered in the logbook.
5. The use of such doors shall be authorised by the officer of the watch.
6. Cables for control and power systems to power operated watertight doors and their status indication should comply with the requirements of Pt.4, Ch.8, Sec.1.17.

2.6.6 Types of doors in Table 2.6.4

Power operated, sliding or rolling	POS
Power operated, hinged	POH
Sliding or rolling	S
Hinged	H

2.6.7 Control

a) Local

All doors, except those which are to be permanently closed at sea, are to be capable of being opened and closed by hand, (and by power, where applicable) locally, from both sides of the doors, with the ship listed to either side. In the case of passenger ships, it is to be possible to close the door from a position above the bulkhead deck with an all round crank motion or some other movement providing the same degree of safety.

For passenger ships, the angle of list at which operation by hand is to be possible is 15 degrees or 20 degrees if the ship is allowed to heel up to 20 degrees during intermediate stages of flooding.

For cargo ships, the angle of list at which operation by hand is to be possible is 30 degrees.

b) Remote

Where indicated in Table 2.6.4, doors are to be capable of being remotely closed by power from the bridge. Where it is necessary to start the power unit for operation of the watertight door, means to start the power unit is also to be provided at remote control stations. The operation of such remote control is to be in accordance with Pt.4, Ch.8, Clauses 10.1.9 to 10.1.12.

2.6.8 Indication

Where shown in Table 2.6.4, position indicators are to be provided at all remote operating positions as well as locally, on both sides of the doors, to show whether the doors are open or closed and if applicable, with all dogs/cleats fully and properly engaged.

The door position indicating system is to be of self-monitoring type and means for testing of the indicating system is to be provided at the position where the indicators are fitted.

An indication (i.e. red light) should be placed locally showing that the door is in remote control mode ("doors closed mode"). Special care should be taken in order to avoid potential danger when passing through the door. Signboard/instructions should be placed in way of the door advising how to act when the door is in "doors closed" mode.

2.6.9 Alarms

Doors which are to be capable of being remotely closed are to be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever such a door is remotely closed. For passenger ships the alarm shall sound for at lest 5 s but not more than 10 s before the door begins to move and shall continue sounding until the door is completely closed. In the case of remote closure by hand operation, an alarm is required to sound only while the door is actually moving.

In passenger areas and areas of high ambient noise, the audible alarms are to be supplemented by visual signals at both sides of the doors.

2.6.10 Notices

As shown in Table 2.6.4, doors which are normally closed at sea but not provided with means of remote closure, are to have notices fixed to both sides of the doors stating, 'To be kept closed at sea'. Doors which are to be permanently closed at sea are to have notices fixed to both sides stating, 'Not to be opened at sea'.

2.6.11 Fire doors

Watertight doors may also serve as fire doors but need not be fire-tested when intended for use below the bulkhead deck. Where such doors are used at locations above the bulkhead deck they are to in addition to complying with the provisions applicable to fire doors at the same locations, also comply with means of escape provisions of Pt.6, Ch.4, Sec.2.

Where a watertight door is located adjacent to a fire door, both doors are to be capable of independent operation, remotely if required and from both sides of the each door.

2.6.12 Testing

a) Doors which become immersed by an equilibrium or intermediate waterplane are to be subjected to a hydrostatic pressure test. (See also Ch.18, Table 3.3.1).

b) For large doors intended for use in the watertight subdivision boundaries of cargo spaces, structural analysis may be accepted in lieu of pressure testing. Where such doors utilise gasket seals, a prototype pressure test to confirm that the compression of the gasket material is capable of accommodating any deflection, revealed by the structural analysis, is to be carried out.

c) Doors which are not immersed by an equilibrium or intermediate waterplane but become intermittently immersed at angles of heel in the required range of positive stability beyond the equilibrium position are to be hose tested.

2.6.13 Pressure testing

The head of water used for the pressure test shall correspond to at least the head measured from the lower edge of the door opening, at the location in which the door is to be fitted in the vessel, to the bulkhead deck or freeboard deck, as applicable, or to the most unfavourable damage waterplane, if that be greater. Testing may be carried out at the factory or other shore based testing facility prior to installation in the ship.

2.6.14 For doors on passenger ships which are normally open and used at sea or which become submerged by the equilibrium or intermediate waterplane, a prototype test shall be conducted, on each side of the door, to check the satisfactory closing of the door against a force equivalent to a water head of at least 1 [m] above the sill on the centre line of the door.

2.6.15 Hose testing

After installation in a ship if pressure test is not carried out, all watertight doors are to be subject to a hose test in accordance with Pt.3, Ch.18. Hose testing is to be carried out from each side of the door unless, for a specific application, exposure to floodwater is anticipated only from one side. Where a hose test is not practicable because of possible damage to machinery, electrical equipment, insulation or outfitting items, it may be replaced by means such as an ultrasonic leak test or an equivalent test.

2.7 Cofferdams

2.7.1 Cofferdams are to be provided between the following spaces to separate them from each other:

- tanks for fuel oil or lubricating oil
- tanks for edible oil
- tanks for fresh water and feed water.

2.7.2 Tanks for lubricating oil are also to be separated by cofferdams from those carrying fuel oil. However, these cofferdams need not be fitted provided that the common boundaries have full penetration welds and the head of lubricating oil is not less than that in the adjacent fuel oil tanks. In this case, a permanent notice is to be displayed near the lubricating oil tank that the oil level is not to be less than that in the adjacent fuel oil tank at any time.

2.8 Fore peak spaces

2.8.1 In ships of 400 GT and above, compartments forward of the collision bulkhead are not to be arranged for carriage of oil and other inflamable liquids.

Section 3

Structural Arrangement and Details

3.1 General

3.1.1 Oil fuel or oil carried as cargo in the deep tanks is to have a flash point of 60°C and above in closed cup test. Where tanks are intended for other liquid cargoes of a special nature the scantlings and arrangements will be considered in relation to the nature of the cargo.

3.1.2 If cargo is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead (or deck) is to be insulated, or equivalent arrangements provided.

3.1.3 The continuity of bulkhead longitudinals within a distance of 0.15D from the bottom or the strength deck is to be maintained in accordance with Ch.3, Sec.5.1.1.

3.1.4 Carlings, girders or floors are to be fitted below the corrugated bulkheads at their supports. These supporting members are to be aligned to the face plate strips of the corrugations.

3.1.5 The weld connections are to comply with the requirements of Ch.17.

3.2 Wash bulkheads

3.2.1 A centreline wash bulkhead is to be fitted in peak spaces used as tanks, where the breadth of the tank exceeds 0.5B and also in deep tanks used for fuel oil extending from side to side.

3.2.2 The area of perforations is generally to be between 5% to 10% of the total area of bulkhead. The plating is to be suitably stiffened in way of the openings.

3.3 Supporting bulkheads

3.3.1 Bulkheads or parts thereof supporting deck structure are also to be designed as pillars. The permissible axial loads and buckling strength are to be calculated in accordance with Ch.3, Sec.6. In calculating sectional properties the width of attached plating is not to be taken in excess of 40 times the plate thickness. Also see Ch.9, Sec.5.1.1.

Section 4

Design Loads

4.1 Watertight bulkhead loads

4.1.1 The design pressure 'p', for ordinary watertight bulkheads is given by:

$$p = 0.01\ h\ [N/mm^2]$$

where,

h = the vertical distance [m] from the center of loading to the freeboard deck.

Where it is shown by damage stability calculations that the deepest equilibrium damaged waterline in way of the load point is below the freeboard deck, a reduced value of 'h' may be considered.

For the definition of 'loadpoint' see Ch.4, Sec.3.

4.1.2 Watertight bulkheads enclosing hold spaces to carry water ballast are to be treated as tank bulkheads.

4.1.3 The design pressure for the end bulkheads of bulk cargo spaces are to be obtained as per Ch.4, Sec.3.4.3.

4.2 Tank bulkhead loads

4.2.1 The design pressure 'p' for tank bulkheads are normally to be taken as the greater of

$$p = 0.01\left(1 + \frac{0.5}{C_b} k_v\ a_o\right) h_s\ [N/mm^2]$$

$= 6.7\ h_p\ .\ 10^{-3}\ [N/mm^2]$

$= 0.01\ h_s + p_o\ [N/mm^2]$

where,

a_o = as given in Ch.4, Sec.1.

h_p = vertical distance [m] from the loadpoint to the top of the air pipe.

h_s = vertical distance [m] from the loadpoint to the top of the tank or hatchway.

$p_o = (0.02L + 0.6) \times 10^{-2}\ [N/mm^2]$ for L< 90 [m]

$= 0.024\ [N/mm^2]$ for $L \geq 90$ [m]

However, in mechanically propelled cargo ships of 500 GT and above and passenger ships, for tanks forming part of the watertight subdivision, p_0 is to be taken as not less than 0.024 [N/mm²].

For this purpose, tanks meeting any of the following conditions are to be considered as part of watertight subdivision:

a) Tanks considered watertight in damage stability calculations.

b) Double bottom tanks, peak tanks or tanks bounded by main transverse watertight bulkheads required as per 2.1.1.

Where automatic pressure valves are fitted, p_o is not to be taken as less than the valve release pressure.

4.2.2 For longitudinal bulkheads (and transverse bulkheads at sides) in way of wide tanks, the design pressure is normally given by the greater of 'p' according to 4.2.1 and

$$p = 6.7\ (h_s + \phi\ b) \times 10^{-3}\ [N/mm^2]$$

where,

b = athwartship distance [m] from the load point to the tank corner at tank top which is situated furthest from the load point. [See Fig.3.2.2 in Ch.8].

ϕ= roll angle as defined in Ch.4 Sec.2.2.1.

For transverse bulkheads (and longitudinal bulkheads at ends) in way of tanks of length > 0.15 L, the design pressure is normally given by greater of 'p' according to 4.2.1 and

$$p = 6.7\left(h_s + \theta\, l\right) x 10^{-3}\ [N/mm^2]$$

where,

l = larger longitudinal distance in 'm' from the load point to the tank corner at the top of the tank which is furthermost away from the load point.

θ = pitch angle as defined in Ch.4, Sec.2.1.1.

4.2.3 The pressure 'p' in tanks which may be filled between 20 percent and 90 percent of the tank heights is to be taken as the greater of that according to 4.2.1, 4.2.2 and the relevant values given as follows:

- for strength members located within 0.25 l_t from the end bulkheads 'p' is not to be taken as less than:

$$p = \rho[4 - 0.005L]\, l_t \times 10^{-3} \quad [N/mm^2]$$

where,

ρ = density of liquid in the tank [t/m³]

l_t = distance [m] between transverse tank bulkheads or effective transverse wash bulkheads at the height at which the strength member is located. Transverse web frames covering part of the tank cross-section (e.g. wing tank structures in tankers) may be regarded as wash bulkheads for this purpose.

- for strength members located within 0.25 b_t from the tank side bulkheads the pressure 'p' is not to be less than

$$p = \rho[3 - 0.01B]\, b_t \times 10^{-3} \quad [N/mm^2]$$

where,

b_t = distance [m] between tank side bulkheads or effective wash bulkheads at the height at which the strength member is located.

- for tanks with $l_t > 0.13L$ and/or $b_t > 0.56B$, p will be specially considered.

4.2.4 The pressure 'p' on girder web panels in cargo tanks or ballast tanks is not to be taken as less than 0.02 [N/mm²].

4.3 Wash bulkheads loads

4.3.1 The design pressure 'p' for wash bulkheads is not to be taken as less than

$$p = [4 - 0.005L]\, l_t \times 10^{-3} \quad [N/mm^2]$$

- for transverse bulkheads, and

$$p = [3 - 0.01B]\, b_t \times 10^{-3} \quad [N/mm^2]$$

- for longitudinal bulkheads.

where,

l_t = the greater of the distances between the adjacent transverse bulkheads.

b_t = the greater of the distances between the adjacent longitudinal bulkheads.

Section 5

Plating and Stiffeners

5.1 Bulkhead plating

5.1.1 The thickness 't' of the bulkhead plating is not to be less than the minimum thickness given in 5.1.2 nor less than

$$t = \frac{s\sqrt{p}}{2\sqrt{\sigma}} + t_c \ [mm]$$

where,

p = applicable design pressure as given in Sec.4.

σ = as per Table 5.1.1 for longitudinal bulkheads.

= 160/k for transverse tank bulkheads and collision bulkhead;

= 220/k for ordinary transverse watertight bulkheads.

= 190/k for transverse dry bulk cargo bulkheads

Table 5.1.1 : 'σ' values for longitudinal bulkhead plating

Region	Framing system	At neutral axis	At strength deck or at bottom	Between neutral axis and strength deck or bottom
0.4L amidships	Vertical	140/k	(175 - 120 f_s)/k max. 120/k	To be obtained by linear interpolation
	Longitudinal	160/k	(185 - 100 f_s)/k max. 120/k	To be obtained by linear interpolation
Within 0.1L from ends	160/k			
Elsewhere	To be obtained by linear interpolation between allowable values at regions specified above.			

5.1.2 The minimum thickness requirement of the bulkhead plating is given by

$$t = (5.0 + cL)\sqrt{k} + t_c \text{ [mm]}$$

where,

c = 0.02 for longitudinal bulkheads and bulkheads in cargo tank area and in peak tanks

= 0.01 for other bulkheads.

5.1.3 The plate thickness of corrugated bulkheads is not to be less than that required according to 5.1.1 and 5.1.2. The spacing 's' to be used in the calculation of the plating thickness is to be taken as the greater of 'b' or 'c' where 'b' and 'c' are indicated in Fig.5.1.3.

For built up corrugation bulkheads, where the thickness of the flange and web are different, the thickness of the wider plating is also not to be less than

$$t = \sqrt{\frac{s^2 . p}{2\sigma} - (t_a - t_c)^2} + t_c \quad \text{[mm]}$$

where,

t_a = thickness of adjacent plating [mm] not to be taken greater than t.

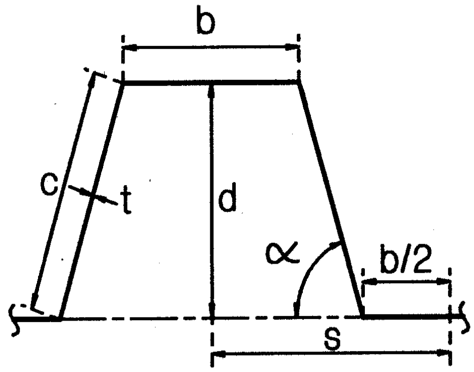


Fig. 5.1.3 : Corrugated bulkhead

5.1.4 The longitudinal bulkhead plating within 0.1D from bottom or strength deck is also to comply with the requirements of buckling strength given in Ch.3, Sec.6. For approximate thickness requirements for plane bulkheads see Ch.7, Sec.4.2.2 and Ch.9, Sec.4.1.3 respectively.

For corrugated bulkheads, the critical buckling stress σ_c is to be taken as

$$\sigma_c = \sigma_F \left[1 - \frac{\sigma_F}{c} \left(\frac{s}{1000\, t_f} \right)^2 \right]$$

where,

σ_F = minimum yield stress in [N/mm^2]

c = 2.42 (1 + t_w/t_f)

t_w = net web plate thickness [mm]

t_f = net flange thickness [mm]

s = width [mm] of the corrugation flange.

5.1.5 In way of stern tubes, doubling plate of same thickness as the corresponding strake is to be fitted, or the strake thickness is to be increased by at least 60 per cent.

5.2 Longitudinals

5.2.1 The section modulus of continuous longitudinal stiffeners and corrugations is not to be less than:

$$Z = \frac{spl^2}{m\sigma} x\, 10^3 + Z_c \ [cm^3]$$

where,

p = applicable design pressure given in Sec.4.

m = 12

σ = (215 - 135 f_s f_z)/k, max. 160/k [N/mm^2] for tank and dry bulk cargo bulkhead longitudinals within 0.4L amidships

= (225 - 135 f_s f_z)/k, max. 160/k [N/mm^2] for ordinary watertight bulkhead longitudinals within 0.4L amidships

= 160/k for longitudinals within 0.1L from ends.

For longitudinals between the regions specified above σ may be obtained by linear interpolation.

5.2.2 The thickness of the web and flange is not to be less than the minimum plating thickness requirements stipulated in 5.1.2.

5.2.3 The rule section modulus of a corrugated bulkhead element is to be obtained according to 5.2.1 taking 's' as shown in Fig.5.1.3.

5.2.4 The actual section modulus of a corrugated bulkhead element may be obtained in accordance with the following:

$$Z_{actual} = \frac{t.d\,(b + c/3)}{2000} \ [cm^3]$$

where, t,d,b and c are as shown in Fig.5.1.3 [mm].

5.3 Vertical and transverse stiffeners on tank bulkheads, collision bulkheads, dry bulk cargo bulkheads and wash bulkheads

5.3.1 The section modulus of bulkhead stiffeners is not to be less than:

$$Z = \frac{spl^2}{m\sigma} x\, 10^3 + Z_c \ [cm^3]$$

where,

p = applicable design pressure given in Sec.4.

m = 10 for transverse stiffeners and vertical stiffeners which may be considered fixed at both ends

= 7.5 for vertical stiffeners simply supported at one or both ends

= 10 for horizontal corrugation fixed at ends

=13 for fixed upper end of vertical corrugation

= 20 for non-fixed upper end of vertical corrugation

= m_s for vertical corrugation, lower end to stool

$= \frac{8m_s}{m_s - 4}$ for vertical corrugation at middle of span; [m] not more than 13

where,

$$m_s = 7.5\left[1 + \frac{4b_c\left(H_s + \frac{h_{db}}{2}\right)}{b_s\, l_{db}}\right]$$

b_c = breadth of stool [m] at the lower end of corrugation

b_s = breadth of stool at inner bottom

H_s = height of stool [m]

h_{db} = height of double bottom [m]

l_{db} = length of cargo hold double bottom between stools in [m], not to be taken larger than 6 Hs or 6 h_{db} where there is no stool

σ = 160/k for tank bulkhead and collision bulkhead

= 210/k for dry bulk cargo bulkheads.

5.3.2 The thickness of web and flange is to be as required in 5.1.2.

5.3.3 Actual section modulus of corrugations is to be obtained as per 5.2.4.

5.3.4 Brackets are normally to be fitted at the ends of non-continuous stiffeners. Where stiffeners are sniped at the ends, the thickness of the plating supported by the stiffeners is not to be less than:

t = 1.25 $\sqrt{[(l - 0.0005s)\, s.p.k]} + t_c$ [mm].

5.4 Vertical and transverse stiffeners on ordinary watertight bulkheads

5.4.1 The section modulus of bulkhead stiffeners is not to be less than

$$Z = \frac{spl^2}{m\sigma} \times 10^3$$

where,

p = applicable design pressure given in Sec.4.

m = 16 for stiffeners fixed at both ends

= 12 for stiffeners fixed at one end (lower end in case of vertical stiffeners) and simply supported at the other end.

= 8 for stiffeners simply supported at both ends.
σ = 220/k.

5.4.2 The thickness of web and flange is to be as required in 5.1.2. For sniped ends, the thickness of bulkhead plating is to be as per 5.3.4.

5.4.3 Actual section modulus of corrugations is to be obtained as per 5.2.4.

Section 6

Girders

6.1 General

6.1.1 Bulkhead stringers and deep transverses are to be arranged in line with other primary supporting structure to the adjoining deck, side shell and bottom so as to facilitate the formation of continuous ring structures. Otherwise equivalent scarphing arrangement is to be provided.

6.1.2 The section modulus requirement 'Z' of simple girders is not to be less than:

$$Z = \frac{b.p.S^2 x 10^6}{m\sigma} + Z_c \ [cm^3]$$

where,

m = 12 for continuous longitudinal girders with end attachments in accordance with Ch.3, Sec.5.

= 10 for other girders with end attachments in accordance with Ch.3, Sec.5.

σ = (190 - 135$f_S.f_z$), max 160/k [N/mm^2], for continuous longitudinal girders within 0.4L amidships.

= 160/k [N/mm^2] for continuous longitudinal girders within 0.1L from ends and for vertical or transverse girders on tank and collision bulkheads.

= 220/k for vertical and transverse girders in ordinary watertight bulkheads.

= 210/k for vertical and transverse girders in dry bulk cargo bulkheads.

For continuous longitudinal girders between the regions specified above, 'σ' may be obtained by linear interpolation.

6.1.3 The depth of the girders should not be less than 2.5 times the depth of the cutout (if any) for the passage of continuous stiffeners. The web area requirement (after deduction of the cutouts) at the girder ends is given by:

$$A_w = CkSbP + 0.01\, d_w\, t_c \ [cm^2]$$

where

C = 60 for tank and collision bulkheads

C = 45 for other watertight bulkheads

d_w = depth of web [mm].

However, for lower end of vertical girders value of C to be taken as 80 and 60 respectively.

The web area at middle of span to be not less than 0.5 A_w.

6.1.4 The girders are to be satisfactorily stiffened against buckling in accordance with the requirements given in Ch.3, Sec.6. Tripping brackets are to be fitted in accordance with the requirements given in Ch.3, Sec.4.

6.2 Complex girder system

In addition to satisfying the local requirements specified in 6.1, the scantlings of bulkhead girders, which are a part of a complex girder system in holds for heavy cargo or tanks may have to be based on direct stress analysis.

End of Chapter

Chapter 11

Superstructures, Deckhouses and Bulwarks

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The scantlings of the bulwarks and of the exposed bulkheads of the superstructures and deckhouse are to comply with the requirements of this chapter. The scantlings of the decks of the superstructures and deckhouses are to be in accordance with the requirements of Ch.9, and those of the sides of the superstructures are to be in accordance with the requirements of Ch.8.

1.2 Definitions

1.2.1 For definitions of the terms 'Superstructure' and 'Deckhouse' refer to Ch.1.

1.2.2 Superstructure deck is a deck forming the upper boundary of a superstructure.

Where the summer freeboard is increased such that the resulting draught is not more than that corresponding to the minimum summer freeboard for the same ship from an assumed freeboard deck located at a distance equal to or greater than the standard superstructure height below the actual freeboard deck;

The actual freeboard deck may be treated as the superstructure deck, while considering the requirements given in this chapter.

1.2.3 Where the freeboard is increased in accordance with 1.2.2 above, the first tier above the uppermost continuous deck may be treated as the second tier. The lowest tier is normally the tier that is directly situated on the deck to which the rule depth 'D' is measured.

1.2.4 Long deckhouse is a deckhouse having more than 0.2L of its length within 0.4L amidships.

1.3 Symbols

1.3.1 L and k as defined in Ch.1, Sec.2.

L_1 = length of the ship [m], but need not be taken greater than 300 [m].

C_b = block co-efficient as defined in Ch.1. C_b is not to be taken less than 0.6 nor greater than 0.8. When determining aft end bulkheads, situated for'd of amidships, C_b need not be taken as less than 0.8

x = distance, [m], between the after perpendicular and the load point under consideration. When determining the scantlings of the deckhouse sides, the deckhouse is to be subdivided into parts of approximately equal length, not exceeding 0.15L each, and 'x' is to be taken as the distance between AP and the centre of each part considered.

z = the vertical distance [m] from summer load waterline to the load point.

b' = breadth of deckhouse, [m] at the position considered.

B' = actual max. breadth of the ship, [m] on the exposed weather deck at the position considered.

s = spacing of stiffeners [mm].

l = span of stiffener [m].

Section 2

Design Loads

2.1 External pressure

2.1.1 The design pressure for the unprotected sides and ends of superstructures and deckhouses is given by :

$$p = a(bf-z)\, c\, 10^{-2}\ [\mathrm{N/mm^2}]$$

where,

$$a = 2.0 + \frac{L_1}{120}$$

- for unprotected fronts of the lowest tier.

$$= 1.0 + \frac{L_1}{120}$$

- for unprotected fronts of the 2nd tier.

$$= 0.5 + \frac{L_1}{150}$$

- for unprotected fronts of the third tier and for sides and protected fronts of all tiers.

$$= 0.7 - \frac{0.8x}{L} + \frac{L_1}{1000}$$

- for aft ends situated aft of amidships.

$$= 0.5 - \frac{0.4x}{L} + \frac{L_1}{1000}$$

- for aft ends situated forward of amidships.

$$b = 1.0 + \left[\frac{\frac{x}{L} - 0.45}{C_b + 0.2}\right]^2 \quad \text{for } x/L \leq 0.45$$

$$= 1.0 + 1.5\left[\frac{\frac{x}{L} - 0.45}{C_b + 0.2}\right]^2 \quad \text{for } x/L > 0.45$$

$$f = \frac{L}{10}.e^{(-L/300)} + \left[\frac{L}{150}\right]^2 - 1.0 \text{ for } L < 150\ [\mathrm{m}]$$

$$= \frac{L}{10}.e^{(-L/300)} \quad \text{for } 150[\mathrm{m}] \leq L < 300\ [\mathrm{m}]$$

= 11.03 for L $\geq$ 300 [m].

Values of 'f' may be linearly interpolated from Table 2.1.1

c = 1.0 for exposed parts of machinery casings

= 0.3 + 0.7 $\frac{b'}{B'}$ for other bulkheads

The value of (b'/B') is not to be taken less than 0.25.

2.1.2 The design pressure 'p' is not to be taken as less than:

p = 0.025 + 10^{-4} L [N/mm^2] - for lowest tier of unprotected fronts

p = 0.0125 + 0.5 x 10^{-4} L [N/mm^2] - elsewhere

In the above formulae 'L' is not to be taken as less than 50 [m], nor need be taken greater than 250 [m].

Table 2.1.1 : Values of 'f' [m]

L	f	L	f
20	.89	25	1.33
30	1.75	35	2.17
40	2.57	45	2.96
50	3.34	55	3.71
60	4.07	65	4.42
70	4.76	75	5.09
80	5.41	85	5.72
90	6.03	95	6.32
100	6.61	105	6.89
110	7.16	115	7.43
120	7.68	125	7.93
130	8.18	135	8.42
140	8.65	145	8.8
150	9.10	155	9.25
160	9.39	165	9.52
170	9.65	175	9.77
180	9.80	190	10.09
200	10.27	210	10.43
220	10.57	230	10.68
240	10.70	250	10.86
260	10.93	270	10.98
280	11.01	290	11.03
300	11.03		

Section 3

Scantlings

3.1 End bulkheads of superstructures and deckhouses and exposed sides in deckhouses

3.1.1 The thickness 't' of steel plating of the fronts, sides and aft ends of the deckhouses and the front and aft ends of the superstructures corresponding to the design pressure is given by

$t = 0.03\ s\sqrt{p}$ [mm]

3.1.2 The thickness however, is not to be less than :

$t = (5 + 0.01\ L_1)\ \sqrt{k}$ [mm] for the lowest tier;

$t = (4 + 0.01\ L_1)\ \sqrt{k}$ [mm] for upper tiers.

3.1.3 The section modulus Z of stiffeners on fronts, sides and end bulkheads of all erections other than sides of superstructures is not to be less than

$Z = 0.35\ s l^2 p$ [cm^3] in general

For longitudinals on sides of long deck house within 0.4L amidships and at strength deck level

$Z = 0.625\ s l^2\ p$ [cm^3].

The modulus may be linearly decreased to the general value at the first deck above the strength deck and at 0.1L from the perpendiculars.

l is not to be taken less than 2.0 m.

3.1.4 Stiffeners on fronts are to be connected to deck at both ends with a connection area 'a' not less than :

a = 0.07 s p l k [cm^2]

Webs of stiffeners on sides and after ends of the lowest tiers of all erections are to be welded to the deck at both ends.

3.2 Protected machinery casings

3.2.1 The thickness of plating is not to be less than:

t = 0.0085 s √k [mm]

however not less than 6.0 √k [mm] in way of cargo holds

= 0.0065 s √k [mm]

however not less than 5.0 √k [mm] in way of accommodations.

3.2.2 The section modulus 'Z' of stiffeners is not to be less than:

Z = 0.003 sl^2√k [cm^3]

where, l is not to be taken less than 2.5 [m].

3.2.3 Casings supporting one or more decks above are to be adequately strengthened.

Section 4

Structural Arrangement and Details

4.1 Structural continuity

4.1.1 Adequate transverse strength is to be provided to the deckhouses and superstructures by means of transverse bulkheads, girders and web frames.

4.1.2 The front and the after end bulkheads of the superstructures and deckhouses should be effectively supported below by a transverse bulkhead or by a combination of partial bulkheads, girders and pillars. Similarly, the exposed sides and internal bulkheads of various tiers of erections are to be located, as far as practicable, above bulkheads or above deep girders below, or equivalent.

4.1.3 Adequate web frames are to be provided in way of large openings, boat davits and other points of high loading.

4.1.4 All openings cut on the sides are to be substantially framed and have well rounded corners. Continuous coamings or girders are to be fitted below and above doors and similar openings. The size and number of openings on the sides are to be avoided or minimized at the ends of erections situated within 0.4L amidships.

4.1.5 At the ends of superstructures, which have no set-in from the ships' side, and at the ends of poop and bridge, the side plating is to extend beyond the ends of the superstructure, and is to be gradually reduced in height down to the sheer strake. The transition should be smooth and without any discontinuity. The extended plating is to be adequately stiffened, particularly at its upper edge.

4.1.6 Deck girders are to be fitted below the sides of long deckhouses and are to extend at least three frame spaces beyond the deckhouse ends. The depth of the girders is to be at least 100 [mm] greater than the depth of the beams and the girders are to be adequately stiffened at the lower edge.

4.1.7 The connection area between the corners of long deckhouses and deck plating should be increased locally. Deck beams under the corners of deck houses are not to be scalloped for a distance of 0.5 [m] on either side of the corners.

4.2 Navigation bridge visibility

4.2.1 Attention is drawn to Chapter V, Regulation 22 of SOLAS 1994 Amendments regarding Navigation Bridge Visibility requirements, applicable to ships of loadline length equal to or greater than 45 [m].

Section 5

Bulwarks and Guard Rails

5.1 General requirements

5.1.1 Bulwarks or guard rails are to be provided on the exposed parts of the freeboard and superstructure decks and also on the first tier of the deckhouse decks. The height of the bulwarks or guard rails measured above the sheathing, if any, is not to be less than 1.0 [m]. Consideration will be given to cases where this height would interfere with the normal operation of the ship.

5.2 Bulwark construction

5.2.1 Bulwarks are to be stiffened at the upper edge by a strong rail section and supported by stays from the deck. The spacing of stays forward of 0.07L from F.P. is to be not more than 1.2 [m] on Type 'A', Type 'B-60' and Type 'B-100' ships as defined in the ILLC, and not more than 1.8 [m]. on other types. Elsewhere, the bulwark stays are to be not more than 1.8 [m] apart. Where bulwarks are cut in way of a gangway or other openings, stays of increased strength are to be fitted at the ends of the openings.

Bulwark stays are to be supported by, or are to be in line with, suitable underdeck stiffening, which is to be connected by double continuous fillet welds in way of the bulwark stay connection.

Bulwarks are to be adequately strengthened in way of the eyeplates for cargo gear, and in way of the mooring pipes the plating is to be increased in thickness and also adequately stiffened.

5.2.2 Bulwarks are generally not to be welded to the top of the sheerstrake within 0.6L amidships.

5.2.3 Bulwarks should not be cut in way of the breaks of the superstructures, and are also to be arranged to ensure their freedom from main structural stresses. At the ends of the superstructures where the side plating is extended and tapered to align with the bulwark plating, the transition plating is to be suitably stiffened and supported. Where freeing ports or other openings are essential in this plate, they are to be suitably framed and kept well clear of the free edge.

5.3 Bulwark scantlings

5.3.1 The thickness of the bulwark plating is not to be less than that required for the superstructure side plating in the same location if the height of the bulwark is equal to or greater than 1.8 [m]. Where the height of the bulwark is 1.0 [m], the thickness need not exceed 6.0 [mm]. For intermediate bulwark heights the thickness may be obtained by interpolation.

5.3.2 The section modulus 'Z' at the bottom of the bulwark stay is not to be less than:

$Z = (33 + 0.44\ L)\ h^2\ s$ [cm^3]

where,

h = height of the bulwark [m].

s = spacing of bulwark stays [m].

In the calculation of section modulus 'Z', only the material connected to the deck is to be included. The contribution from bulwark plating and/or stay flange may be considered depending upon the construction details.

5.3.3 When the bulwark is subjected to loads from any deck cargo, the scantlings will be specially considered.

5.4 Freeing arrangements

5.4.1 Where bulwarks on the weather portion on freeboard or superstructure decks form wells, provision is to be made for rapidly freeing the decks of water. In general the minimum freeing area "A" on each side of the ship for each well on the freeboard deck is to be given by the following in cases where the sheer in way of the well is standard or greater than standard.

Where, length of the bulwark (l) in the well is less than or equal to 20 [m] -

$A = 0.7 + 0.035\ l$ [m^2];

and where l exceeds 20 [m] -

$A = 0.07\ l$ [m^2];

l not to be taken as greater than 0.7 L_L, where L_L is the loadline length of the vessel (See Ch.1)

If the bulwark is more than 1.2 [m] in average height, the required area is to be increased by 0.004 [m^2] per metre of length of the well for each 0.1 [m] difference in height. If the bulwark is less than 0.9 [m] in average height, the required area may be decreased in the same proportion.

The minimum area for each well on superstructure decks is to be one half of the area given above. Wells on raised quarter decks should be treated as being on freeboard deck.

5.4.2 In ships with no sheer the area of freeing ports as calculated above is to be increased by 50%. Where the sheer is less than standard, percentage of increase to be obtained by linear interpolation.

5.4.3 On a flush deck ship with a substantial deckhouse amidships, it is considered that the deckhouse provides sufficient break to form two wells and that each could be given the required freeing port area based upon the length of the 'well'. It would not then be allowed to base the area upon 0.7 L_L.

For a 'substantial' deckhouse, the breadth of the deckhouse should be at least 80% of the beam of the vessel and the passageways along the sides of the ship should not exceed 1.5 [m] in width.

Where a screen bulkhead is fitted completely across the vessel, at the forward end of a midship deck house, this would effectively divide the exposed deck into wells and no limitation on the breadth of the deckhouse is considered necessary in this case.

5.4.4 Two thirds of the freeing port area required is to be provided in the half of the well nearest the lowest point of the sheer curve. With zero or little sheer on the exposed freeboard deck or an exposed superstructure deck, it is considered that the freeing port area should be spread along the length of the well.

5.4.5 The effectiveness of the freeing port area in bulwarks required in 5.4.1 above depends on the free flow across the deck of a ship. Where there is no free flow due to the presence of a continuous trunk or hatchway coaming the freeing area in bulwarks is to be calculated as per Table 5.4.5. The area of freeing ports at intermediate breadths shall be obtained by linear interpolation.

Table 5.4.5

Breadth of hatchway or trunk in relation to the breadth of the ship	Area of freeing ports in relation to the total area of bulwark
40% or less	20%
75% or more	10%

5.4.6 The freeflow area on deck is the net area of gaps between hatchways, and between hatchways and superstructures and deckhouses upto the actual height of the bulwark.

The freeing port area in bulwarks should be assessed in relation to the net flow area as follows:

(i) If the freeflow area is not less than the freeing area calculated from 5.4.5 above as if the hatchway coamings were continuous, then the minimum freeing port area calculated from 5.4.1 & 5.4.2 should be deemed sufficient.

(ii) If the freeflow area is equal to or less than the freeing area calculated from 5.4.1 & 5.4.2, the minimum freeing area in the bulwarks should be determined from 5.4.5.

(iii) If the freeflow area is smaller than calculated from 5.4.5 but greater than calculated from 5.4.1 and 5.4.2, the minimum freeing port area should be determined from the following formula.

$$F = F_1 + F_2 - f_p \text{ [m}^2\text{]}$$

where,

F_1 = minimum freeing area [m^2] calculated from 5.4.1 and 5.4.2

F_2 = minimum freeing area [m^2] calculated from 5.4.5

f_p = the total net area of passages and gaps between hatch ends and superstructures or deckhouses up to the actual height of bulwark [m^2].

5.4.7 All such openings in the bulwark are to be protected by rails or bars spaced not more than 230 [mm] apart. If shutters are fitted to freeing ports ample clearance is to be provided to prevent jamming. Hinges are to have pins or bearings of non-corrodible materials. If shutters are fitted with securing devices, these appliances are to be of approved construction.

5.4.8 Type A ships and Type B ships with trunks are to have open rails fitted for at least half the length of the exposed parts of the freeboard deck or other effective freeing arrangements are to be provided. It is considered that a freeing port area in the lower part of the bulwarks, of 33% of the total area of the bulwark provides the 'other effective freeing arrangements' and may be considered equivalent to the requirement of 50% open rails.

However, for Type A ships which have superstructures connected by trunks open rails are to be fitted for the whole length of the exposed part of the freeboard deck.

For Type B ships with freeboards reduced by not more than 60% of the difference between the freeboards given in Tables B and A of the International Loadline Convention, 1966; there shall be freeing port area in the lower part of the bulwarks equal to at least 25% of the total area of the bulwarks.

The upper edge of the sheer strake is to be kept as low as possible.

5.5 Freeing ports in way of wells in combination with open superstructures

5.5.1 In the case of vessels having open superstructures on the freeboard or superstructure decks, which open to wells formed by bulwarks on the peripheries of the open decks, the minimum freeing port areas on each side of the ship for the open superstructure A_s and for the open well A_w are to be determined as follows:

a) For $l_t > 20$ [m]:

$A_w = (0.07\ l_w + A_c)\ .\ S_c\ .\ H_c\ [m^2]$

$A_s = 0.07\ .\ S_c\ .\ b_o\ \{1 - (l_w/l_t)^2\}\ .\ H_c\ [m^2]$

b) For $l_t \leq 20$ [m]

$A_w = (0.7 + 0.035\ l_w + A_c)\ .\ S_c\ .\ H_c\ [m^2]$

$A_s = (0.7 + 0.035\ l_t)\ .\ S_c\ .\ b_o/l_t\ \{1 - (l_w/l_t)^2\}\ .\ H_c\ [m^2]$

where,

$l_t = l_w + l_s$ where,

l_w = length of open deck enclosed by bulwarks [m] and

l_s = length of the common space within the open superstructure [m]

b_o = breadth of the openings in the end bulkhead of the enclosed superstructure.

A_c = area correction for bulwark height:

$A_c = 0.04\ l_w\ (h_b - 1.2)\ [m^2]$ for $h_b > 1.2$ [m]

$= 0.04\ l_w\ (h_b - 0.9)\ [m^2]$ for $h_b < 0.9$ [m]

$= 0.0\ [m^2]$ for $0.9 \leq h_b \leq 1.2$ [m]

h_b = height of bulwark [m]

S_c = sheer correction factor

= 1.5 for no sheer

= 0.0 for standard sheer;

For intermediate values of sheer S_c to be interpolated.

H_c = correction factor for distance of well deck above the freeboard deck;

$= 0.5\ h_s/h_w$; not greater than 1.0;

h_w = the height of the well deck above the freeboard deck [m]

h_s = standard superstructure height defined in Table 7.4.1 of Ch.12 [m].

5.6 Guard rails

5.6.1 The guard rails fitted as specified in Sec.5.1.1 should meet the following requirements:

a) Fixed, removable or hinged stanchions shall be fitted about 1.5 [m] apart.

b) At least every third stanchion shall be supported by a bracket or stay.

   In lieu of at least every third stanchion supported by stay, alternatively any of the following options may be provided: (See Fig.5.6.1):

   i) at least every third stanchion of increased breadth : $k\ .\ b_s = 2.9\ .\ b_s$

   ii) at least every second stanchion of increased breadth : $k\ .\ b_s = 2.4\ .\ b_s$

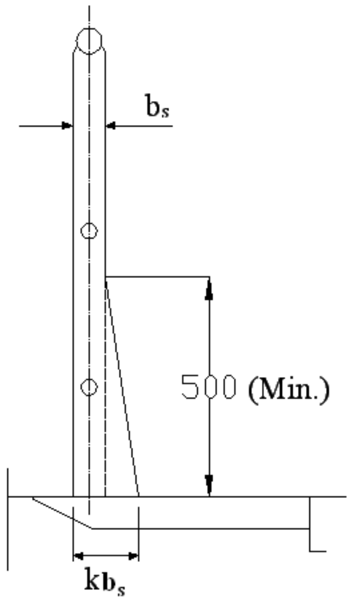


Fig.5.6.1 : Guardrail stanchion

iii) every stanchion of increased breadth : $k . b_s = 1.9 . b_s$

where,

b_s = breadth of normal stanchion according to the design standard.

Stanchions with increased breadth to be aligned with member below deck which is to be min. 100 x 12 flatbar welded to deck by double continuous fillet weld. The stanchions with increased breadth need not be aligned with under deck structure for deck plating exceeding 20 [mm].

c) Wire ropes may only be accepted in lieu of guardrails in special circumstances and then only in limited lengths.

d) Lengths of chain may be accepted in lieu of guard rails if they are fitted between two fixed stanchions and/or bulwarks.

e) The clear opening below the lowest course of the guard rails is not to exceed 230 [mm]. Where this course is not measured from the deck, but from the sheerstrake or a waterway bar, which is not in the same vertical plane as the rails, the length of opening is the diagonal distance between the lowest of the rails and the top of the sheerstrake or waterway bar. The other courses are not to be more than 380 [mm] apart. Where rounded gunwales are fitted the guard rail supports are to be placed on the flat of the deck, as close as possible to the beginning of the curvature of the gunwale.

f) Wires shall be made taut by means of turnbuckles.

g) Removable or hinged stanchions shall be capable of being locked in the upright position.

5.7 Protection of crew requirements for specific types

Note : Some Administrations may have more stringent requirements for protection of crew than those given below.

5.7.1 Protection of crew shall be provided by at least one of the means denoted in Table 5.7.1.

Acceptable arrangements referred to in the table are defined as follows:

a) A well lighted and ventilated underdeck passage (clear opening 0.8 [m] wide, 2 [m] high) as close as practicable to the freeboard deck, connecting and providing access to the locations in question.

b) On or near the centreline of a ship a permanent and efficiently constructed gangway fitted at the level of the superstructure deck, providing a continuous platform at least 0.6 [m] in width and a non-slip surface, with guard rails extending on each side throughout its length. Guard rails shall be at least 1 [m] high with courses as required in 5.6.e) above and supported by stanchions spaced not more than 1.5 [m]; a foot stop shall be provided.

<table>
<tr><th colspan="8">Table 5.7.1 : Protection of crew</th></tr>
<tr><th rowspan="2">Type of Ship</th><th colspan="2" rowspan="2">Location of access in ships</th><th rowspan="2">Assigned summer freeboard</th><th colspan="4">Acceptable arrangements according to type of freeboard assigned:</th></tr>
<tr><th>Type A</th><th>Type B-100</th><th>Type B-60</th><th>Type B&B+</th></tr>
<tr><td rowspan="4">All ships other than Oil Tankers, Chemical Tankers and Gas Carriers</td><td>1.1
1.1.1</td><td>Access to Midship Quarters
Between poop and bridge, or</td><td>≤ 3000 mm</td><td>a
b
e</td><td>a
b
e</td><td>a
b
c(1)
e
f(1)</td><td rowspan="4">a
b
c(1)
c(2)
c(4)
d(1)
d(2)
d(3)
e
f(1)
f(2)
f(4)</td></tr>
<tr><td>1.1.2</td><td>Between poop and deckhouse containing living accommodation or navigating equipment, or both</td><td>> 3000 mm</td><td>a
b
e</td><td>a
b
e</td><td>a
b
c(1)
c(2)
e
f(1)
f(2)</td></tr>
<tr><td>1.2
1.2.1
1.2.2</td><td>Access to Ends
Between poop and bow (if there is no bridge)
Between bridge and bow, or</td><td>≤ 3000 mm</td><td>a
b
c(1)
e
f(1)</td><td>a
b
c(1)
c(2)
e
f(1)
f(2)</td><td>a
b
c(1)
c(2)
e
f(1)
f(2)</td></tr>
<tr><td>1.2.3
1.2.4</td><td>Between a deckhouse containing living accommodation or navigating equipment, or both, and bow, or
In the case of a flush deck vessel, between crew accommodation and the forward and after ends of ships</td><td>> 3000 mm</td><td>a
b
c(1)
d(1)
e
f(1)</td><td>a
b
c(1)
c(2)
d(1)
d(2)
e
f(1)
f(2)</td><td>a
b
c(1)
c(2)
c(4)
d(1)
d(2)
d(3)
e
f(1)
f(2)
f(4)</td></tr>
<tr><td rowspan="3">Oil Tankers, Chemical Tankers and Gas Carriers</td><td>2.1
2.1.1
2.1.2</td><td>Access to Bow
Between poop and bow or
Between a deckhouse containing living accommodation or navigating equipment, or both, and bow, or</td><td>≤ (A_f + H_s)*</td><td colspan="4">a
e
f(1)
f(5)</td></tr>
<tr><td>2.1.3</td><td>In the case of a flush deck vessel, between crew accommodation and the forward end of ship</td><td>> (A_f+ H_s)*</td><td colspan="4">a
e
f(1)
f(2)</td></tr>
<tr><td>2.2
2.2.1</td><td>Access to After End
In the case of a flush deck vessel, between crew accommodation and the after end of ship</td><td></td><td colspan="4">As required in 1.2.4 for other types of ships</td></tr>
<tr><td colspan="8">* A_f : the minimum summer freeboard calculated as type A ship regardless of the type of freeboard actually assigned.
H_s : the standard height of superstructure as defined in Pt.3, Ch.12, 7.4.1.

Note : Deviations from some or all of these requirements or alternative arrangements for such cases as ships with very high gangways (i.e. certain gas carriers) may be allowed subject to agreement case-by-case with the relevant flag Administration.</td></tr>
</table>

c) A permanent walkway at least 0.6 [m] in width fitted at freeboard deck level consisting of two rows of guardrails with stanchions spaced not more than 3 [m]. The number of courses of rails and their spacing to be as required by 5.6.e above. On Type B ships hatchway coamings not less than 0.6 [m] in height may be regarded as forming one side of the walkway, provided that between the hatchways two rows of guard rails are fitted.

d) A 10 [mm] minimum diameter wire rope lifeline supported by stanchions about 10 [m] apart, or A single handrail or wire rope attached to hatchcoamings, continued and adequately supported between hatchways.

e) A permanent and efficiently constructed gangway fitted at or above the level of the superstructure deck on or as near as practicable to the center line of the ship:

- located so as not to hinder easy access across the working areas of the deck;

- providing a continuous platform at least 1.0 [m] in width;

- constructed of fire resistant and non-slip material;

Note : FRP gratings used in lieu of steel gratings for safe access to tanker bows are to possess:

- low flame spread characteristics and are not to generate excessive quantities of smoke and toxic products, as per the FTP Code; and

- adequate structural fire integrity as per national / international standards.

- fitted with guard rails extending on each side throughout its length; guard rails should be at least 1.0 [m] high with courses as required by 5.6.e above and supported by stanchions spaced not more than 1.5 [m];

- provided with a foot stop on each side;

- having openings, with ladders where appropriate, to and from the deck. Openings should not be more than 40 [m] apart;

- having shelters of substantial construction set in way of the gangway at intervals not exceeding 45 [m] if the length of the exposed deck to be traversed exceeds 70 [m]. Every such shelter should be capable of accommodating at least one person and be so constructed as to afford weather protection on the forward, port and starboard sides.

f) A permanent and efficiently constructed walkway fitted at freeboard deck level on or as near as practicable to the center line of the ship having the same specifications as those for a permanent gangway listed in (e) except for foot-stops. On Type B ships (certified for the carriage of liquids in bulk), with a combined height of hatch coaming and fitted hatch cover of together not less than 1 [m] in height the hatchway coamings may be regarded as forming one side of the walkway, provided that between the hatchways two rows of guard rails are fitted.

Alternative transverse locations to 'c', 'd' and 'f' above: (indicated as (1) to (5) in Table 5.7.1).

(1) At or near center line of ship; or fitted on hatchways at or near center line of ship.

(2) Fitted one each side of the ship

(3) Fitted on one side, provision being made for fitting on either side

(4) Fitted on one side only.

(5) Fitted on each side of the hatchways as near to the center line as practicable.

The following requirements also to be met:

i. In all cases where wire ropes are fitted, adequate devices are to be provided to ensure their tautness

ii. Wire ropes may only be accepted in lieu of guard rails in special circumstances and then only in limited lengths.

iii. Lengths of chain may only be accepted in lieu of guard rails if fitted between two fixed stanchions.

iv. Where stanchions are fitted, every 3rd stanchion is to be supported by a bracket or stay.

v. Removable or hinged stanchions shall be capable of being locked in the upright position.

vi. A means of passage over obstructions, if any, such as pipes or other fittings of a permanent nature, should be provided.

vii. Generally, the width of the gangway or deck level walkway should not exceed 1.5 [m].

viii. For tankers less than 100 [m] in length, the minimum width of the gangway platform or deck level walkway fitted in accordance with arrangement (e) or (f), respectively, may be reduced to 0.6 [m].

Section 6

Means of Embarkation and Disembarkation

6.1 General

6.1.1 Ships constructed on or after 1 Jan 2010 are to be provided with means of embarkation and disembarkation such as gangways and accommodation ladders, for use in port and in port related operations in accordance with the requirements of this section. However, compliance with particular provisions may be waived by the Administration, if it is deemed to be unreasonable or impractical.

6.1.2 Where means of embarkation and disembarkation other than those specifically covered in the section are fitted, an equivalent level of safety is to be provided.

6.1.3 For all ships (i.e. constructed before, on or after 1 Jan 2010), means of embarkation and disembarkation are to be inspected and maintained in suitable condition for the intended purpose. Requirements for surveys of such means are given in Part 1, Chapter 2 of the rules.

6.2 Construction

6.2.1 Accommodation ladders and gangways for means of embarkation and disembarkation which are provided on board ships constructed on or after 1 Jan 2010 are to meet applicable international standards such as ISO 5488:1979, “Shipbuilding – accommodation ladders”, ISO 7061:1993, “Shipbuilding – aluminium shore gangways for seagoing vessels” and/or national standards and/or other requirements recognized by the Administration. Such accommodation ladders and gangways fitted on ships constructed before 1 Jan 2010, which are replaced after that date, should, in so far as is reasonable and practicable, comply with the requirements of this section.

6.2.2 The structure of the accommodation ladders and gangways and their fittings and attachments should be such as to allow regular inspection, maintenance of all parts and, if necessary, lubrication of their pivot pin. Special care should be taken to ensure that the welding work is carried out satisfactorily.

6.2.3 The construction and test of accommodation ladder winches are to be in accordance with applicable international standards such as ISO 7364:1983 “Shipbuilding and marine structures – deck machinery – accommodation ladder winches”.

6.3 Installation

6.3.1 Location

6.3.1.1 As far as practicable, the means of embarkation and disembarkation are to be sited clear of the working area and are not to be placed where cargo or other suspended loads may pass overhead.

6.3.2 Lighting

6.3.2.1 Adequate lighting is to be provided to illuminate the means of embarkation and disembarkation, the position on deck where persons embark or disembark and the controls of the arrangement.

6.3.3 Lifebuoy

6.3.3.1 A lifebuoy equipped with a self-igniting light and a buoyant lifeline is to be available for immediate use in the vicinity of the embarkation and disembarkation arrangement when in use.

6.3.4 Arrangement

6.3.4.1 Each accommodation ladder is to be of such a length to ensure that, at a maximum design operating angle of inclination, the lowest platform will be not more than 600 [mm] above the waterline in the “lightest seagoing condition”, as defined in the following:

“Lightest seagoing condition” is the loading condition with the ship on even keel, without cargo, with 10% stores and fuel remaining and in the case of a passenger ship with the full number of passengers and crew and their luggage.

6.3.4.2 The arrangement at the head of the accommodation ladder is to provide direct access between the ladder and the ship's deck by a platform securely guarded by handrails and adequate handholds. The ladder should be securely attached to the ship to prevent overturning.

6.3.4.3 For ships on which the height of the embarkation / disembarkation deck exceeds 20 [m] above the waterline specified in 6.3.4.1 and on other ships where compliance with the provisions of 6.3.4.1 is considered impractical, an alternative means of providing safe access to the ship or supplementary means of safe access to the bottom platform of the accommodation ladder may be accepted.

6.3.5 Marking

6.3.5.1 Each accommodation ladder or gangway is to be clearly marked at each end with a plate showing the restrictions on the safe operation and loading, including the maximum and minimum permitted design angles of inclination, design load, maximum load on bottom end plate, etc. Where the maximum operational load is less than the design load, it should also be shown on the marking plate.

6.3.6 Test

6.3.6.1 After installation, the winch and the accommodation ladder are to be operationally tested to confirm proper operation and condition of the winch and the ladder after the test.

6.3.6.2 The winch is to be tested as a part of the complete accommodation ladder unit through a minimum of two times hoisting and lowering of the accommodation ladder in accordance with the onboard test requirement specified in applicable international standards such as ISO 7364:1983.

6.3.6.3 Every new accommodation ladder is to be subjected to a static load test of the specified maximum working load upon installation.

6.3.7 Positioning

6.3.7.1 Gangways are not to be used at an angle of inclination greater than 30° from the horizontal and accommodation ladders are not to be used at an angle greater than 55° from the horizontal, unless designed and constructed for use at angles greater than these and marked as such, as required by 6.3.5.1.

6.3.7.2 Gangways are not to be secured to ship's guardrails unless they have been designed for that purpose. If positioned through an open section of bulwark or railings, any remaining gaps are to be adequately fenced.

6.3.7.3 Adequate lighting for means of embarkation and disembarkation and for the immediate approaches are to be ensured from the ship and/or the shore in hours of darkness.

6.3.8 Safety net

6.3.8.1 A safety net is to be mounted in way of the accommodation ladders and gangways where it is possible that a person may fall from them or between the ship and quayside.

6.3.9 Verification

6.3.9.1 Upon installation the entire arrangement of the means of embarkation and disembarkation will be verified for compliance with the requirements of this section.

6.4 Inspection and maintenance

6.4.1 The maintenance and inspection requirements for means of embarkation and disembarkation are to be addressed by the ship's safety management system.

6.4.2 The wires used to support the means of embarkation and disembarkation are to be renewed when necessary due to deterioration or at intervals of not more than 5 years, whichever is earlier.

6.4.3 Arrangements should also be made to examine the underside of gangways and accommodation ladders at regular intervals.

6.4.4 All inspections, maintenance work and repairs of accommodation ladders and gangways should be recorded in order to provide an accurate history for each appliance. The information to be recorded appropriately on board should include the date of the most recent inspection, the name of the person or body who carried out that inspection, the due date for the next inspection and the dates of renewal of wires used to support the embarkation and disembarkation arrangement.

End of Chapter

Chapter 12

Openings and Closing Appliances

Contents

Section

Section 1

General

1.1 Scope

1.1.1 This Chapter applies to all ship types in general. Additional requirements pertaining to special ship types are given in Pt.5.

1.1.2 The requirements conform, where applicable, to those of the International Convention on Load Lines, 1966 (ILLC, 1966) as amended by the 1988 protocol, as amended in 2003. Reference should also be made to the additional requirements of the National Authority of the country in which the ship is to be registered.

Requirements for hatch covers and coamings of bulk carriers, ore carriers and combination carriers are given in Pt.5, Ch.1.

1.2 Definitions

1.2.1 Where the freeboard is increased in accordance with Ch.11, Sec.1.2.2 the actual freeboard deck may be treated as the superstructure deck, while considering the requirements given in this chapter. The requirements of hatches and doors on the weather decks are given with respect to two basic positions as follows:

Position 1

- Upon exposed freeboard and raised quarter decks for their entire length and
- Upon exposed superstructure decks situated forward of the 0.25L from the F.P.

Position 2

- Upon exposed superstructure decks situated abaft the 0.25L from the F.P and located at least one standard height of superstructure above the freeboard deck, and.
- Upon exposed superstructure decks located forward of 0.25L from the F.P. and at least two standard heights of superstructure above the freeboard deck.

Note : The upper limit of the vertical extent of Position 2 need not be considered to exceed two standard superstructure heights at locations abaft the 0.25L from the F.P. and three standard superstructure heights forward of 0.25L from the F.P.

1.2.2 σ_y = the minimum upper yield strength of the material [N/mm^2].

1.3 Hatch cover and coaming load model

Structural assessment of hatch covers and hatch coamings is to be carried out using the design loads, defined in this section:

Definitions:

L = Rule length of ship [m] as defined in Ch1. Sec.2

L_L = Loadline length of ship [m] as defined in Ch1. Sec.2

x = Longitudinal co-ordinate of mid point of assessed structural member measured from aft end of length L or L_L, as applicable

D_{min} = the least moulded depth, [m] as defined in Ch.1, Sec.2

h_N = Standard superstructure height [m]

= $1.05 + 0.01\ L_L$, $1.8 \le h_N \le 2.3$

(Also see Table 7.5.1)

1.3.1 Vertical design weather load

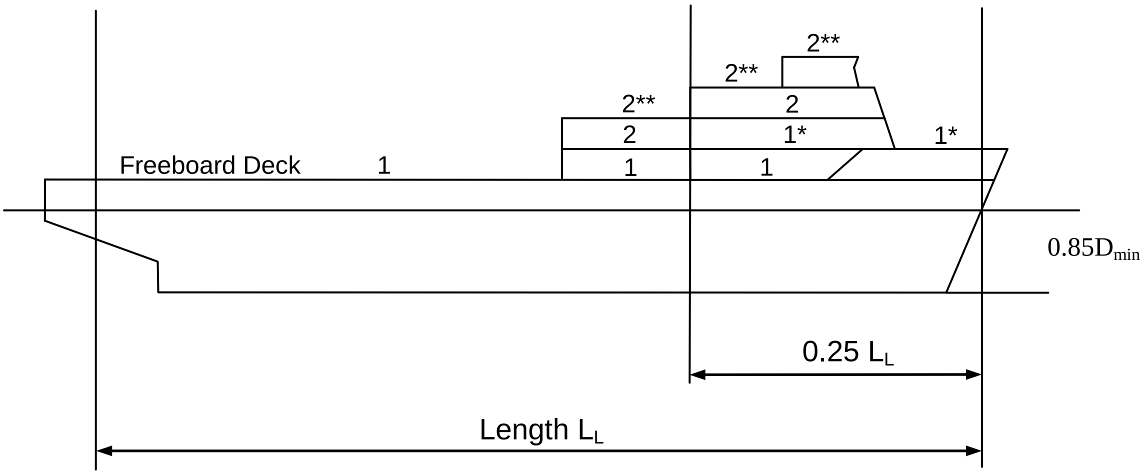
The pressure p_H, [N/mm²], on the hatch cover panels is given in Table 1.3.1. The vertical design weather load need not be combined with cargo loads given in 1.3.3 and 1.3.4.

In Fig.1.3.1.1 the positions 1 and 2 for the purpose of design weather loads are illustrated for an example ship.

Where an increased freeboard is assigned, the design load for hatch covers according to Table 1.3.1 on the actual freeboard deck may be as required for a superstructure deck, provided the summer freeboard is such that the resulting draught will not be greater than that corresponding to the minimum freeboard calculated from an assumed freeboard deck situated at a distance at least equal to the standard superstructure height h_N below the actual freeboard deck. (See Fig.1.3.1.2).

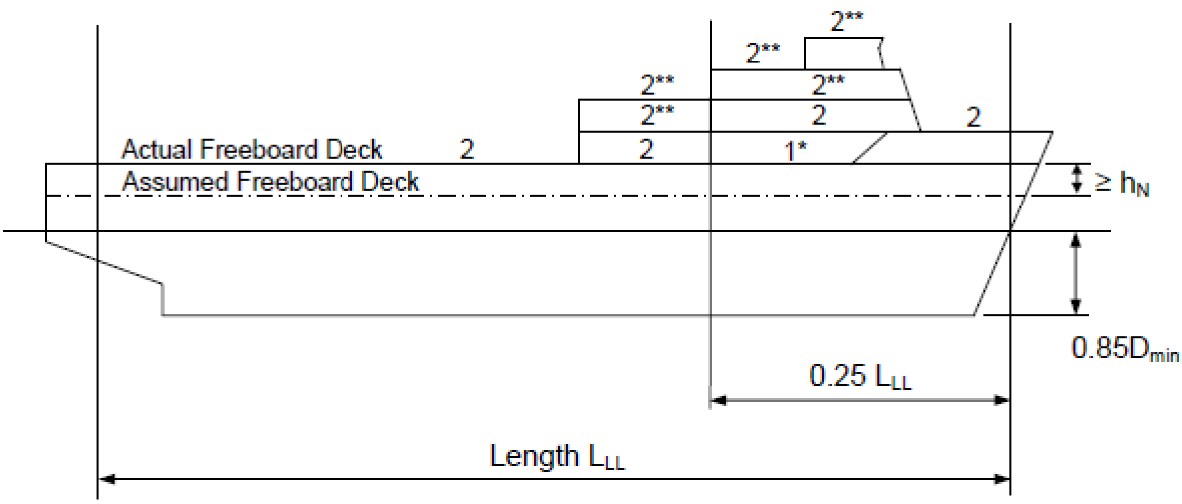
Table 1.3.1 : Design load p_H of weather deck hatches

Position	**Design load p_H [N/mm^2]**	
	$\frac{x}{L_L} \le 0.75$	$0.75 < \frac{x}{L_L} \le 1.0$
1	for 24 m ≤ L_L ≤ 100 m	
	$\frac{9.81x10^{-3}}{76} \cdot \left(1.5 \cdot L_L + 116\right)$	on freeboard deck $\frac{9.81x10^{-3}}{76} \cdot \left[\left(4.28\,x\,L_L + 28\right) \cdot \frac{x}{L_L} - 1.71\,x\,L_L + 95\right]$
		upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck $\frac{9.81x10^{-3}}{76} \cdot \left(1.5\,x\,L_L + 116\right)$
	for L_{LL} > 100 m	
	$9.81 \cdot 3.5.10^{-3}$	on freeboard deck for type B ships according to ICLL $9.81x10^{-3}\left[\left(0.0296 \cdot L_1 + 3.04\right) \cdot \frac{x}{L_L} - 0.0222 \cdot L_1 + 1.22\right]$
		on freeboard deck for ships with less freeboard than type B according to ICLL $9.81x10^{-3}\left[\left(0.1452 \cdot L_1 + 8.52\right) \cdot \frac{x}{L_L} - 0.1089 \cdot L_1 + 9.89\right]$ L_1 = L_L but not more than 340 [m]
		upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck $9.81\,x\,3.5.10^{-3}$
2	for 24 m ≤ L_L ≤ 100 m	
	$\frac{9.81\,x\,10^{-3}}{76} \cdot \left(1.1\,x\,L_L + 87.6\right)$	
	for L_L > 100 m	
	$9.81x2.6.10^{-3}$	
	upon exposed superstructure decks located at least one superstructure standard height above the lowest Position 2 deck $9.81x2.1$	



* reduced load upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck
** reduced load upon exposed superstructure decks of vessels with L_L > 100 m located at least one superstructure standard height above the lowest Position 2 deck

Fig. 1.3.1.1 : Positions 1 and 2 for design weather loads



* reduced load upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck
** reduced load upon exposed superstructure decks of vessels with L_{LL} > 100 m located at least one superstructure standard height above the lowest Position 2 deck

Fig. 1.3.1.2 : Positions 1 and 2 for design weather loads for an increased freeboard

1.3.2 Horizontal design weather load

The horizontal design weather load for determining the scantlings of outer edge girders (skirt plates) of weather deck hatch covers and of hatch coamings is:

$$p_A = a \cdot c \cdot (b \cdot c_L \cdot f - z).10^{-3} \ [\text{N/mm}^2]$$

f = $\frac{L}{25} + 4.1$ for L < 90 [m]

= $10.75 - \left(\frac{300 - L}{100}\right)^{1.5}$

for $90[\text{m}] \le \text{L} < 300[\text{m}]$

= 10.75

for $300[\text{m}] \le \text{L} < 350[\text{m}]$

= $10.75 - \left(\frac{L - 350}{150}\right)^{1.5}$ for $350[\text{m}] \le \text{L} \le 500[\text{m}]$

c_L = $\sqrt{\frac{L}{90}}$ for L < 90 [m]

= 1 for $\text{L} \ge 90[\text{m}]$

a = $20 + \frac{L_1}{12}$

for unprotected front coamings and hatch cover skirt plates

= $10 + \frac{L_1}{12}$

for unprotected front coamings and hatch cover skirt plates, where the distance from the actual freeboard deck to the summer load line exceeds the minimum non-corrected tabular freeboard according to ICLL by at least one standard superstructure height h_N

= $5 + \frac{L_1}{15}$

for side and protected front coamings and hatch cover skirt plates

= $7 + \frac{L_1}{100} - 8 \cdot \frac{x'}{L}$

for aft ends of coamings and aft hatch cover skirt plates abaft amidships

= $5 + \frac{L_1}{100} - 4 \cdot \frac{x'}{L}$

for aft ends of coamings and aft hatch cover skirt plates forward of amidships

L_1 = L, need not be taken greater than 300 [m]

b = $1.0 + \left(\frac{\frac{x'}{L} - 0.45}{C_B + 0.2}\right)^2$

for $\frac{x'}{L} < 0.45$

= $1.0 + 1.5 \cdot \left(\frac{\frac{x'}{L} - 0.45}{C_B + 0.2}\right)^2$

for $\frac{x'}{L} \ge 0.45$

$0.6 \le C_B \le 0.8$, when determining scantlings of aft ends of coamings and aft hatch cover skirt plates forward of amidships, C_B need not be taken less than 0,8.

x' = distance [m] between the transverse coaming or hatch cover skirt plate considered and aft end of the length L. When determining side coamings or side hatch cover skirt plates, the side is to be subdivided into parts of approximately equal length, not exceeding 0,15 L each, and x' is to be taken as the distance between aft end of the length L and the centre of each part considered.

z = vertical distance [m] from the summer load line to the midpoint of stiffener span, or to the middle of the plate field

c = $0.3 + 0.7 \cdot \frac{b'}{B'}$

b' = breadth of coaming [m] at the position considered

B' = actual maximum breadth of ship [m] on the exposed weather deck at the position considered.

b'/B' is not to be taken less than 0,25.

The design load p_A is not to be taken less than the minimum values given in Table 1.3.2.

Table 1.3.2 : Minimum design load p_{Amin}

L	p_{Amin} [N/mm²] for	
	unprotected fronts	elsewhere
≤ 50	$30 \cdot 10^{-3}$	$15 \cdot 10^{-3}$
> 50 < 250	$\left(25+\frac{L}{10}\right).10^{-3}$	$\left(12.5+\frac{L}{20}\right).10^{-3}$
≥ 250	$50 \cdot 10^{-3}$	$25 \cdot 10^{-3}$

Note: The horizontal weather design load need not be included in the direct strength calculation of the hatch cover, unless it is utilized for the design of substructures of horizontal support according to 4.4.3

1.3.3 Cargo loads

1.3.3.1 Distributed loads

The load on hatch covers due to distributed cargo loads p_L, [N/mm²], resulting from heave and pitch (i.e. ship in upright condition) is to be determined according to the following formula:

$$p_L = p_C(1+a_V) \text{ [N/mm²]}$$

where:

p_c = uniform cargo load [N/mm²]

a_V = vertical acceleration addition as follows:

$$a_V = F \cdot m$$

$$F = 0.11 \cdot \frac{v_0}{\sqrt{L}}$$

m = $m_0 - 5(m_0 - 1)\frac{x}{L}$ for $0 \leq \frac{x}{L} \leq 0.2$

= 1.0 for $0.2 < \frac{x}{L} \leq 0.7$

= $1 + \frac{m_0 + 1}{0.3}\left[\frac{x}{L} - 0.7\right]$ for $0.7 < \frac{x}{L} \leq 1.0$

m_0 = 1.5 + F

v_o = maximum speed at summer load line draught, v_o is not to be taken less than $\sqrt{L}$ [knots]

1.3.3.2 Point loads

The load *P*, [kN] due to a concentrated force P_s [kN] except for container load, resulting from heave and pitch (i.e. ship in upright condition) is to be determined as follows:

$$P = P_S(1+a_V) \text{ [kN]}$$

1.3.4 Container loads

1.3.4.1 The loads defined in 1.3.4.2 and 1.3.4.4 are to be applied where containers are stowed on the hatch cover.

1.3.4.2 The load *P* [kN], applied at each corner of a container stack, and resulting from heave and pitch (i.e. ship in upright condition) is to be determined as follows:

$$P = 9.81\,\frac{M}{4}(1 + a_V)$$

where:

a_V = acceleration addition according to 1.3.3.1

M = maximum designed mass of container stack [t]

1.3.4.3 The loads, [kN], applied at each corner of a container stack, and resulting from heave, pitch, and the ship's rolling motion (i.e. ship in heel condition) are to be determined as follows , (see also Fig.1.3.4):.

$$A_z = 9.81\frac{M}{2}\cdot(1+a_V)\cdot\left(0.45 - 0.42\frac{h_m}{b}\right) \text{[kN]}$$

$$B_z = 9.81\frac{M}{2}\cdot(1+a_V)\cdot\left(0.45 + 0.42\frac{h_m}{b}\right) \text{[kN]}$$

$$B_y = 2.4 \cdot M \text{ [kN]}$$

a_V = acceleration addition according to 1.3.3.1

M = maximum designed mass of container stack [t],

$= \sum W_i$

h_m = designed height of centre of gravity of stack above hatch cover top [m], may be calculated as weighted mean value of the stack, where the centre of gravity of each tier is assumed to be located at the centre of each container,

$=\sum(z_i W_i) / M$

z_i = distance from hatch cover top to the centre of i^{th} container [m]

W_i = weight of i^{th} container [t]

b = distance between midpoint of foot points [m]

A_Z, B_Z = support forces [kN] in z-direction at the forward and aft stack corners

B_y = support force [kN] in y-direction at the forward and aft stack corners

When strength of the hatch cover structure is assessed by grillage analysis according to 3.7, h_m and z_i need to be taken above the hatch cover supports. Force B_y does not need to be considered in this case.

Values of A_z and B_z applied for the assessment of hatch cover strength are to be shown in the drawings of the hatch covers.

Note;
It is recommended that container loads as calculated above are considered as limit for foot point loads of container stacks in the calculations of cargo securing (container lashing).

1.3.4.4 Load cases with partial loading

The load cases defined in 1.3.4.2 and 1.3.4.3 are also to be considered for partial non homogeneous loading which may occur in practice, e.g. where specified container stack places are empty. For each hatch cover, the heel directions, as shown in Table 1.3.4.4, are to be considered.
The load case *partial loading of container hatch covers* can be evaluated using a simplified approach, where the hatch cover is loaded without the outermost stacks, that are located completely on the hatch cover. If there are additional stacks that are supported partially by the hatch cover and partially by container stanchions then the loads from these stacks are also to be neglected, refer Table 1.3.4.4. Partial loading of container hatch covers. In addition, the case where only the stack places supported partially by the hatch cover and partially by container stanchions are left empty is to be assessed in order to consider the maximum loads in the vertical hatch cover supports. It may be necessary to also consider partial load cases where more or different container stack places are left empty.

1.3.4.5 Mixed stowage of 20 [ft] and 40 [ft] containers on hatch covers

1.3.4.5.1 In the case of mixed stowage (20 [ft] + 40 [ft] container combined stack), the foot point forces at the fore and aft end of the hatch cover are not to be higher than resulting from the design stack weight for 40 [ft] containers, and the foot point forces at the middle of the cover are not to be higher than resulting from the design stack weight for 20 [ft] containers.

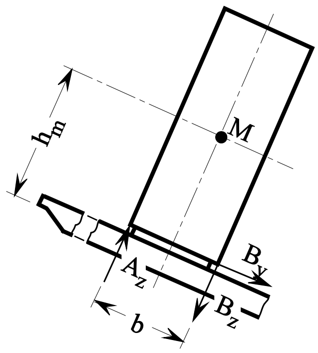
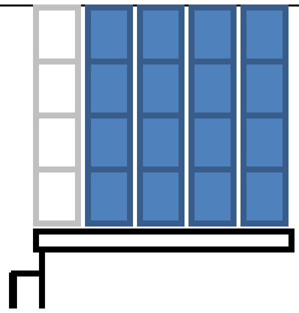
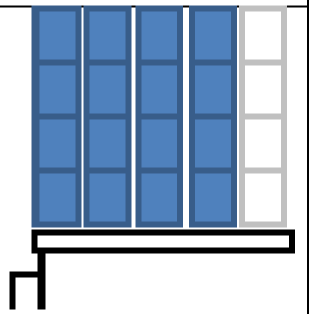
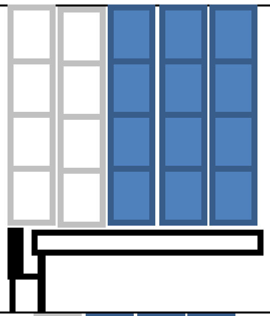
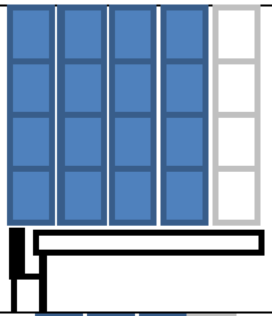
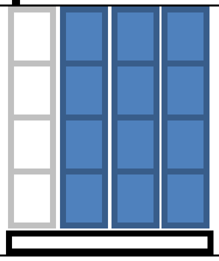
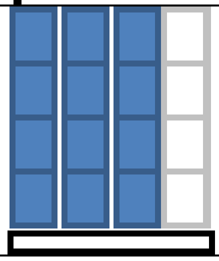


Fig. 1.3.4 : Forces due to container loads

Table 1.3.4.4 : Partial loading of container hatch covers

Heel direction	←	→
Hatch covers supported by the longitudinal hatch coaming with all container stacks located completely on the hatch cover		
Hatch covers supported by the longitudinal hatch coaming with the outermost container stack supported partially by the hatch cover and partially by container stanchions		
Hatch covers not supported by the longitudinal hatch coaming (center hatch covers)		

1.3.5 Loads due to elastic deformations of the ship's hull

Hatch covers, which in addition to the loads according to 1.3.1 to 1.3.4 are loaded in the ship's transverse direction by forces due to elastic deformations of the ship's hull, are to be designed such that the sum of stresses does not exceed the permissible values given in 3.3.1.

1.4 Corrosion addition for hatch covers and hatch coamings

The scantling requirements of the this chapter imply the following general corrosion additions t_c as per Table 1.4:

Table 1.4 : Corrosion additions t_c for hatch covers and hatch coamings

Application	Structure	t_c [mm]
Weather deck hatches of container ships, car carriers, paper carriers, passenger vessels	Hatch covers	1.0
	Hatch coamings	1.0
Weather deck hatches of all other ship types (Also see 1.1.2)	Hatch covers in general	2.0
	Weather exposed plating and bottom plating of double skin hatch covers	1.5
	Internal structure of double skin hatch covers and closed box girders	1.0
	Hatch coamings not part of the longitudinal hull structure	1.5
	Hatch coamings part of the longitudinal hull structure	1.0
	Coaming stays and stiffeners	1.5

1.5 Steel renewal

1.5.1 Steel renewal is required where the gauged thickness is less than t_{net} + 0.5 [mm] for:

- Single skin hatch covers
- The plating of double skin hatch covers, and
- Coaming structures for which corrosion additions t_c is provided in Table 1.4

1.5.2 Where the gauged thickness is within the range t_{net} + 0.5 [mm] and t_{net} + 1.0 [mm], coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating is to be maintained in GOOD condition.

1.5.3 For the internal structure of double skin hatch covers, thickness gauging is required when hatch cover top or bottom plating renewal is to be carried out or when this is deemed necessary, at the discretion of the individual class society's surveyor, on the basis of the plating corrosion or deformation condition. In these cases, steel renewal for the internal structures is required where the gauged thickness is less than t_{net}.

1.5.4 For corrosion addition t_S = 1.0 [mm] the thickness for steel renewal is t_{net} and the thickness for coating or annual gauging is when gauged thickness is between t_{net} and t_{net} + 0.5 [mm]. For coaming structures, the corrosion additions t_c of which are not provided in Tab. 1.4, steel renewal and coating or annual gauging are to be specially considered.

Section 2

Hatch Coamings

2.1 Coaming heights

2.1.1 The height of the coamings for hatchways closed by weathertight covers is to be not less than

- 600 [mm] in Position 1
- 450 [mm] in Position 2

Coaming heights are to be measured from the upper surface of the deck or top of the deck sheathing if fitted.

2.1.2 The height of coamings less than that required as per 2.1.1 may be accepted on special consideration provided the construction of the hatchcovers is such as to ensure that the safety of the ship is not impaired in any sea condition. Such reduced coaming heights will also have to be approved by the concerned National Authorities.

2.1.3 Height of coamings may be required to be increased on certain ships e.g., ships of Type 'B-100' or Type 'B-60' where it is found necessary to satisfy the requirements of floatability stipulated in the ILLC, 1966.

2.2 Hatch coaming construction

2.2.1 Hatchside coamings are to extend to the lower edge of the deck beams. Side coamings not forming a part of continuous girders, are to extend two frame spaces beyond the hatch ends below the deck.

2.2.2 Hatch end coamings when not in line with the deck transverses are to extend below the deck, at least three longitudinal frame spaces beyond the side coaming.

2.2.3 Continuous hatchway coamings or coamings forming an effective part of the deck girder system are to be made from steel of same tensile strength as that of the deck plating.

2.2.4 If the junction of hatch coamings forms a sharp corner, the side and end coamings are to be extended in the form of tapered brackets in longitudinal and transverse directions respectively. Alternatively tapered brackets may be omitted, provided that the hatch coamings at the corners of the hatchways are well rounded and are joined to the deck by full penetration welds. Suitable supporting brackets are to be provided if the deck overhang at the corner is excessive.

2.2.5 Extension brackets or rails arranged approximately in line with the cargo hatch side coamings and intended for the stowage of steel hatch covers are not to be welded to deckhouse, masthouse or to each other unless they form a part of the longitudinal strength members.

2.2.6 Hatch coamings and supporting structures are to be adequately stiffened to resist the loading from hatch covers, in longitudinal, transverse and vertical directions.

2.2.7 The stresses in the under deck structures induced by the load transmitted by the stays are not to be greater than the allowable stresses for coaming stays indicated in 2.5.2.

2.2.8 The coamings are to be satisfactorily stiffened against buckling.

2.2.9 Materials for hatch coaming are to satisfy the requirements of Part 2, Ch 2.

2.3 Hatch coaming strength criteria

2.3.1 Local net plate thickness of coamings

The net thickness of weather deck hatch coamings shall not be less than the larger of the following values:

$$t = 0.0142 \,.\, s\sqrt{\frac{p_A.10^3}{0.95.\sigma_F}} \text{ [mm]}$$

$$t_{min} = 6 + \frac{L_1}{100} \text{ [mm]}$$

s = stiffener spacing [mm]

L_1 = L, need not be taken greater than 300 [m]

σ_F = minimum yield stress [N/mm^2]

Longitudinal strength aspects are to be verified according to Ch.5.

2.4 Net scantling of secondary stiffeners of coamings

The stiffeners must be continuous at the coaming stays. For stiffeners with both ends constraint, the elastic net section modulus Z [cm^3] and net shear area A_s, [cm^2], calculated on the basis of net thickness, is not be less than:

$$Z = \frac{83}{\sigma_F}.s.l^2.p_A \quad [cm^3]$$

$$A_s = \frac{10.s.l.p_A}{\sigma_F} \quad [cm^2]$$

l = secondary stiffener span, [m], to be taken as the spacing of coaming stays

s = stiffener spacing [mm]

For sniped stiffeners of coaming at hatch corners section modulus and shear area at the fixed support have to be increased by 35%. The gross thickness of the coaming plate at the sniped stiffener end shall not be less than:

$$t = 19.6.\sqrt{\frac{p_A .10^{-3}.s.(1000l - 0.5s)}{\sigma_F}} \quad [mm]$$

Horizontal stiffeners on hatch coamings, which are part of the longitudinal hull structure, are to be designed according to Ch.10, Sec.5.2.

2.5 Coaming stays

Coaming stays are to be designed for the loads transmitted through them and permissible stresses according to 3.3.1

2.5.1 Coaming stay section modulus and web thickness

At the connection with deck, the net section modulus Z [cm^3] and the gross thickness t_w [mm], of the coaming stays designed as beams with flange (example 1 and 2 are shown in Figure 2.5.1) are to be taken not less than:

$$Z = \frac{526}{\sigma_F}.e.h_s^2.p_A.10^3 \quad [cm^3]$$

$$t_w = \frac{2}{\sigma_F}.\frac{e.h_s.p_A}{h_w} + t_c \quad [mm]$$

e = spacing of coaming stays [m]

h_s = height of coaming stay [m]

h_w=web height of coaming stay at its lower end [m]

t_c = corrosion addition [mm], according to 1.4

For other designs of coaming stays, such as those shown in Figure 2.5.1, example 3 and 4, the stresses are to be determined through a grillage analysis or FEM. The calculated stresses are to comply with the permissible stresses according to 3.1.1.

Coaming stays are to be supported by appropriate substructures. Face plates may only be included in the calculation if an appropriate substructure is provided and welding provides an adequate joint.

Webs are to be connected to the deck by fillet welds on both sides with a throat thickness of $a=0.44t_w$.

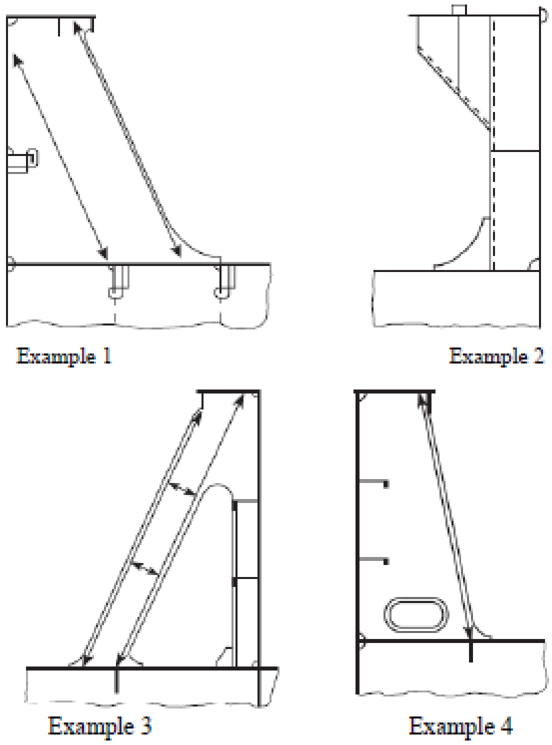


Fig.2.5.1 : Examples of coaming stays

2.5.2 Coaming stays under friction load

For coaming stays, which transfer friction forces at hatch cover supports, fatigue strength is to be considered. (Also see 4.4.2).

2.6 Further requirements for hatch coamings

2.6.1 Longitudinal strength

Hatch coamings which are part of the longitudinal hull structure are to be designed according to the requirements of Ch.5.

For structural members welded to coamings and for cutouts in the top of coamings sufficient fatigue strength is to be verified.

Longitudinal hatch coamings with a length exceeding 0.1L [m] are to be provided with tapered brackets or equivalent transitions and a corresponding substructure at both ends. At the end of the brackets they are to be connected to the deck by full penetration welds of minimum 300 [mm] in length.

2.6.2 Local details

Design of local details not covered in this section are to be suitable for the purpose of transferring the loads on the hatch covers to the hatch coamings and through them, to the deck structures below. Hatch coamings and supporting structures are to be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.

Structures under deck are to be checked against the load transmitted by the stays.

Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the requirements of Ch.17 and Ch.2 respectively.

2.6.3 Stays

On ships carrying cargo on deck such as timber, coal or coke, the stays are to be spaced not more than 1.5 [m] apart.

2.6.4 Extend of coaming plates

2.6.4.1 Coaming plates are to extend to the lower edge of the deck or hatch side girders are to be fitted that extend to the lower edge of the deck breams. Extended coaming plates and hatch side girders are to be flanged or fitted with face bars or half-round bars. Figure 2.6.4 gives an example.

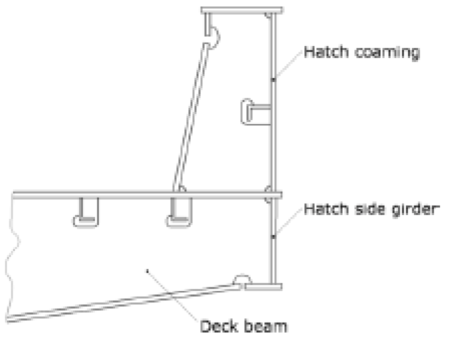


Fig.2.6.4 : Example of hatch side girder

2.6.5 Drainage arrangement at the coaming

If drain channels are provided inside the line of gasket by means of a gutter bar or vertical extension of the hatch side and end coaming, drain openings are to be provided at appropriate positions of the drain channels.

Drain openings in hatch coamings are to be arranged with sufficient distance to areas of stress concentration (e.g. hatch corners, transitions to crane posts).

Drain openings are to be arranged at the ends of drain channels and are to be provided with non-return valves to prevent ingress of water from outside. It is unacceptable to connect fire hoses to the drain openings for this purpose.

If a continuous outer steel contact between cover and ship structure is arranged, drainage from the space between the steel contact and the gasket is also to be provided for.

Section 3

Hatch Covers

3.1 General

3.1.1 The type of hatchcovers a) to e) as described below may be used as per Table 3.1.1 on the weathertight decks of various ship types mentioned in ILLC, 1966 as amended by the 1988 protocol, as amended in 2003.

Table 3.1.1 : Applicability of hatchcover type

Types of hatch covers	**Types of ships as per ILLC, 1966**				
	'A'	**'B-100'**	**'B-60'**	**'B'**	**'B+'**
a	No	Yes	Yes	Yes	Yes
b	No	No	No	Yes	Yes
c	No	No	No	No	Yes
d	Yes	Yes	Yes	Not applicable	
e	Yes	Yes	Yes	Yes	Yes

Hatch Cover Types :

'**a**' : Steel plated cargo hatch covers stiffened by webs or stiffeners and secured by clamping devices. Weathertightness is to be ensured by means of gaskets. Hatch covers used for holds containing liquid cargoes are also included in this category.

'b' : Steel plated pontoon type cargo hatch covers with internal webs and stiffeners extending over the full width of the hatchway. Weather-tightness is to be achieved by tarpaulins.

'c' : Wood or steel hatch covers used in conjunction with the portable beams. Weathertightness to be obtained by tarpaulins.

'**d**' : Access hatch covers for cargo oil tanks and adjacent spaces. The hatch covers are to be of steel and gasketed.

'**e**' : Access hatch covers other than 'd'. For Types 'A', 'B-100' and 'B-60' ships, the covers are to be of steel, and weathertightness is to be ensured by means of gaskets.

Note : Modern hatch cover designs of lift-away-covers are in many cases called pontoon covers. This definition does not fit to the definition above. Modern lift-away hatch cover designs should belong to one of the two categories single skin covers or double skin cover.

3.1.2 Tween deck hatch covers may be any of the types defined in 3.1.1, but need not be weathertight unless fitted to deep tank or water ballast holds or compartments, in which case the covers are to be of type (a) and oil tight or watertight as appropriate.

3.1.3 Materials for hatch covers are to satisfy the requirements of Part 3, Ch 2. Material Class

I is to be applied for top plate, bottom plate and primary supporting members.

3.1.4 The secondary stiffeners and primary supporting members of the hatch covers are to be continuous over the breadth and length of the hatch covers, as far as practical. When this is not practical, appropriate arrangements are to be adopted to ensure sufficient load carrying capacity. Sniped end connections are not to be used.

The spacing of the primary supporting members parallel to the direction of secondary stiffeners is not to exceed 1/3 of the span of the primary supporting members. When strength calculation is carried out by FE analysis using plane strain or shell elements, this requirement can be waived.

3.1.5 Load bearing connections between the hatch cover panels are to be fitted for the purpose of restricting the relative vertical displacements.

3.2 General strength criteria

3.2.1 The scantlings of the hatch cover plating, secondary stiffeners and primary supporting members are to be determined as per 3.4, 3.5 and 3.6 respectively using the design loads given in 1.3.

3.2.2 Hatchcovers of special construction and arrangement e.g. covers designed and constructed as a grillage, covers supported along more than two opposite edges and covers supporting other covers, may require submission of direct strength calculation taking into account the arrangement of stiffeners and the supporting members.

When a beam or a grillage analysis is used, the secondary stiffeners are not to be included in the attached flange area of the primary members.

3.3 Permissible stresses and deflections

3.3.1 Stresses

The equivalent stress σ_V in steel hatch cover structures related to the net thickness shall not exceed 0.8 σ_F, where σ_F is the minimum yield stress, [N/mm^2], of the material. For design loads according to 1.3.2 to 1.3.5, the equivalent stress σ_V related to the net thickness shall not exceed 0.9 σ_F when the stresses are assessed by means of FEM.

For steels with a minimum yield stress of more than 355 [N/mm^2], the value of σ_F to be applied will be specially considered.

For grillage analysis, the equivalent stress may be taken as follows:

$$\sigma_V = \sqrt{\sigma^2 + 3\tau^2} \quad \text{[N/mm}^2\text{]}$$

σ = normal stress [N/mm^2]

τ = shear stress [N/mm^2]

For FEM calculations, the equivalent stress may be taken as follows:

$$\sigma_V = \sqrt{\sigma_x{}^2 - \sigma_x \cdot \sigma_y + \sigma_y{}^2 + 3\tau^2} \quad \text{[N/mm}^2\text{]}$$

σ_X = normal stress, [N/mm^2], in x-direction

σ_Y = normal stress, [N/mm^2], in y-direction

τ = shear stress, [N/mm^2], in the x-y plane

Indices x and y are coordinates of a two-dimensional Cartesian system in the plane of the considered structural element.

In case of FEM calculations using shell or plane strain elements, the stresses are to be read from the centre of the individual element. It is to be observed that, in particular, at flanges of unsymmetrical girders, the evaluation of stress from element centre may lead to non-conservative results. Thus, a sufficiently fine mesh is to be applied in these cases or, the stress at the element edges is not to exceed the allowable stress. Where shell elements are used, the stresses are to be evaluated at the mid plane of the element.

Stress concentrations are to be assessed to the satisfaction of IRS.

3.3.2 Deflection

The vertical deflection of primary supporting members due to the vertical design weather load according to 1.3.1 is to be not more than $0.0056 \cdot l_g$ [m] where l_g [m] is the greatest span of primary supporting members.

Note: *Where hatch covers are arranged for carrying containers and mixed stowage is allowed, i.e., a 40'-container stowed on top of two 20'-containers, particular attention is to be paid to the deflections of hatch covers. Further the possible contact of deflected hatch covers with in hold cargo has to be observed.*

3.4 Local net plate thickness

The local net plate thickness t, [mm], of the hatch cover top plating is not to be less than:

$$t = F_p .15.8.s\sqrt{\frac{p.10^3}{0.95.\sigma_F}}$$

and to be not less than 1% of the spacing of the stiffener or 6 [mm] if that be greater.

F_p = factor for combined membrane and bending response

= 1.5 in general

= 1.9 . $\frac{\sigma}{\sigma_a}$, for $\frac{\sigma}{\sigma_a}$ ≥ 0.8 for the attached plate flange of primary supporting members

s = stiffener spacing [m]

p = pressure p_H and p_L, [N/mm^2], as defined in 1.3.

σ = maximum normal stress, [N/mm^2], of hatch cover top plating, determined according to Fig.3.2

$\sigma_a = 0.8 . \sigma_F$ [N/mm^2]

For flange plates under compression sufficient buckling strength according to 3.8 is to be demonstrated.

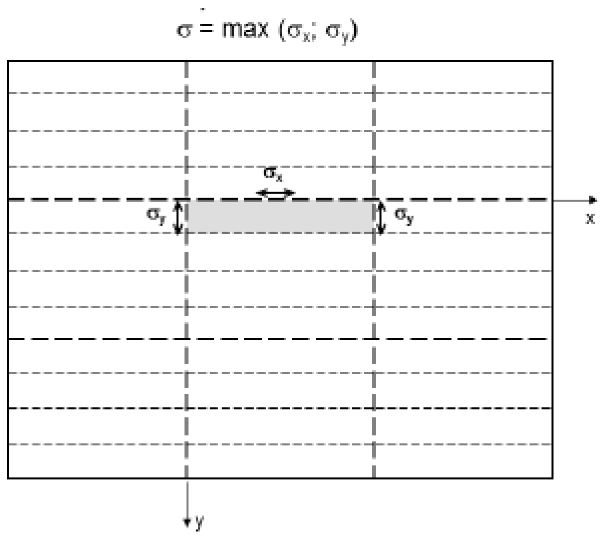


Fig. 3.2 : Determination of normal stress of the hatch cover plating

3.4.1 Local net plate thickness of hatch covers for wheel loading

The local net plate thickness of hatch covers for wheel loading is to be according to Ch.9, Sec.6.

3.4.2 Lower plating of double skin hatch covers and box girders

The thickness to fulfill the strength requirements is to be obtained from the calculation according to 3.7 under consideration of permissible stresses as per 3.3.1.When the lower plating is taken into account as a strength member of the hatch cover, the net thickness [mm], of lower plating is to be taken not less than 5 [mm]. When project cargo in intended to be carried on a hatch cover, the net thickness must not be less than:

t = 6.5 . s [mm]

where,

s = stiffener spacing [m]

Note:

Project cargo means especially large or bulky cargo lashed to the hatch cover. Examples are parts of cranes or wind power stations, turbines, etc. Cargoes that can be considered as uniformly distributed over that hatch cover, e.g., timber, pipes or steel coils need not to be considered as project cargo.

When the lower plating is not considered as a strength member of the hatch cover, the thickness of the lower plating will be specially considered.

3.5 Net scantling of secondary stiffeners

3.5.1 The net section modulus Z and net shear area A_S of uniformly loaded hatch cover stiffeners constrained at both ends must not be less than:

$Z = \frac{104psl^2\ 10^3}{\sigma_F}$ [cm^3], for design load according to 1.3.1

$Z = \frac{93psl^2 10^3}{\sigma_F}$ [cm^3], for design load according to 1.3.3.1

$A_s = \frac{10.8psl10^3}{\sigma_F}$ [cm^2], for design load according to 1.3.1

$A_s = \frac{9.6psl10^3}{\sigma_F}$ [cm^2], for design load according to 1.3.3.1

l = secondary stiffener span, [m], to be taken as the spacing, [m], of primary supporting members or the distance between a primary supporting member and the edge support, as applicable.

s = secondary stiffener spacing [m]

p = pressure p_H and p_L, [N/mm^2], as defined in 1.3.

For secondary stiffeners of lower plating of double skin hatch covers, requirements mentioned above are not applied due to the absence of lateral loads.
The net thickness [mm], of the stiffener (except u-beams/trapeze stiffeners) web is to be taken not less than 4 [mm].

3.5.2 The net section modulus of the secondary stiffeners is to be determined based on an attached plate width assumed equal to the stiffener spacing.

3.5.3 For flat bar secondary stiffeners and anti-buckling stiffeners, the ratio h/t_w is to be not greater than $15.k^{0.5}$, where:

h = height of the stiffener [mm]

t_w = net thickness of the stiffener [mm]
k = $235/\sigma_F$

3.5.4 Stiffeners parallel to primary supporting members and arranged within the effective breadth according to 3.7.1 must be continuous at crossing primary supporting member and may be considered for calculating the cross sectional properties of primary supporting members. It is to be verified that the combined stress of those stiffeners induced by the bending of primary supporting members and lateral pressures does not exceed the permissible stresses according to 3.3.1. The requirements of this paragraph are not applied to stiffeners of lower plating of double skin hatch covers if the lower plating is not considered as strength member.

3.5.6 For hatch cover stiffeners under compression sufficient safety against lateral and torsional buckling according 3.8.3 is to be verified.

3.5.7 For hatch covers subject to wheel loading or point loads stiffener scantlings are to be determined under consideration of the permissible stresses according to 3.3.1 or are to be determined according to Ch.9, Sec.6.

3.6 Net scantling of primary supporting members

3.6.1 Primary supporting members

Scantlings of primary supporting members are obtained from calculations according to 3.7 under consideration of permissible stresses as per 3.3.1.

For all components of primary supporting members sufficient safety against buckling must be verified according to 3.8. For biaxial compressed flange plates this is to be verified within the effective widths according to 3.8.3.2.

The net thickness of webs of primary supporting members is not to be less than:

$t = 6.5 \cdot s$ [mm]

$t_{\min} = 5$ [mm]

s = stiffener spacing [m].

3.6.2 Edge girders (Skirt plates)

Scantlings of edge girders are obtained from the calculations according to 3.7 under consideration of permissible stresses as per 3.3.1.

The net thickness of the outer edge girders exposed to wash of sea is not to be less than the largest of the following values:

$$t = 15.8 . s . \sqrt{\frac{p_A . 10^3}{0.95 . \sigma_F}} \text{ [mm]}$$

$t = 8.5 \cdot s$ [mm]

$t_{min} = 5$ [mm]

p_A = horizontal pressure [N/mm^2] as defined in 1.3.2

s = stiffener spacing [m]

The stiffness of edge girders is to be sufficient to maintain adequate sealing pressure between securing devices. The moment of inertia of edge girders is not to be less than:

$I = 6 \cdot q \cdot s_{SD}{}^4$ [cm^4]

q = packing line pressure [N/mm], minimum 5 [N/mm]

s_{SD} = spacing, [m], of securing devices

3.7 Strength calculations

Strength calculation for hatch covers may be carried out by either, grillage analysis or FEM. Double skin hatch covers or hatch covers with box girders are to be assessed using FEM, refer to 3.7.2.

3.7.1 Effective cross-sectional properties for calculation by grillage analysis

Cross-sectional properties are to be determined considering the effective breadth. Cross sectional areas of secondary stiffeners parallel to the primary supporting member under consideration within the effective breadth can be included, refer Fig. 3.8.3.2.1.

The effective breadth of plating e_m of primary supporting members is to be determined according to Table 3.7.1, considering the type of loading. Special calculations may be required for determining the effective breadth of one-sided or non-symmetrical flanges.

The effective cross sectional area of plates is not to be less than the cross sectional area of the face plate.

For flange plates under compression with secondary stiffeners perpendicular to the web of the primary supporting member, the effective width is to be determined according to 3.8.3.2.

Table 3.7.1 : Effective breadth e_m of plating of primary supporting members

l/e	0	1	2	3	4	5	6	7	≥ 8
e_{m1}/e	0	0.36	0.64	0.82	0.91	0.96	0.98	1.00	1.00
e_{m2}/e	0	0.20	0.37	0.52	0.65	0.75	0.84	0.89	0.90

e_{m1} is to be applied where primary supporting members are loaded by uniformly distributed loads or else by not less than 6 equally spaced single loads

e_{m2} is to be applied where primary supporting members are loaded by 3 or less single loads

Intermediate values may be obtained by direct interpolation.

l length of zero-points of bending moment curve:

$l = l_0$ for simply supported primary supporting members

$l = 0{,}6 \cdot l_0$ for primary supporting members with both ends constraint,

where l_0 is the unsupported length of the primary supporting member

e width of plating supported, measured from centre to centre of the adjacent unsupported fields

3.7.2 General requirements for FEM calculations

For strength calculations of hatch covers by means of finite elements, the cover geometry is to be idealized as realistically as possible. Element size is to be appropriate to account for effective breadth. In no case element width is to be larger than stiffener spacing. In way of force transfer points and cutouts the mesh has to be refined where applicable. The ratio of element length to width is not exceed 4.

The element height of webs of primary supporting member is not to exceed one-third of the web height. Stiffeners and supporting plates against pressure loads, are to be included in the idealization. Stiffeners may be modelled by using shell elements, plane stress elements or beam elements. Anti-buckling stiffeners may be disregarded for the stress calculation.

3.8 Buckling strength of hatch cover structures

For hatch cover structures sufficient buckling strength is to be demonstrated.

The buckling strength assessment of coaming parts is to be done according to Ch.3, Sec.6.

Definitions

a = length of the longer side of a single plate field [mm] (x-direction)

b = breadth of the shorter side of a single plate field [mm] (y-direction)

α = aspect ratio of single plate field

= a / b

n = number of single plate field breadths within the partial or total plate field

t = net plate thickness [mm]

σ_x = membrane stress, [N/mm²], in x-direction

σ_y = membrane stress, [N/mm²], in y-direction

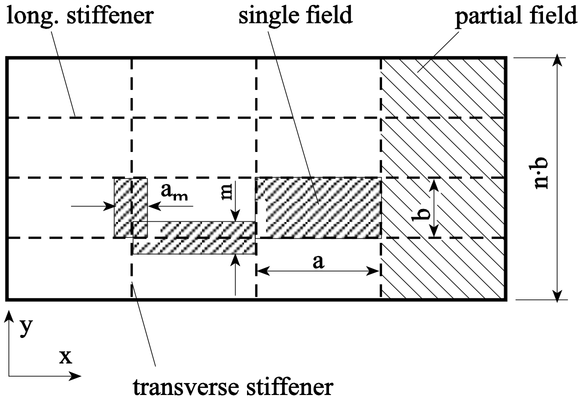
τ = shear stress, [N/mm²], in the x-y plane

E = modulus of elasticity [N/mm²], of the material

= $2.06 \cdot 10^5$ [N/mm^2] for steel

σ_F = minimum yield stress, [N/mm²], of the material

Compressive and shear stresses are to be taken positive, tensile stresses are to be taken negative.



longitudinal : stiffener in the direction of the length a
transverse : stiffener in the direction of the breath b

Fig. 3.8 : General arrangement of panel

Note:

If stresses in the x- and y-direction already contain the Poisson-effect (calculated using FEM), the following modified stress values may be used. Both stresses σ_x^* and σ_y^* are to be compressive stresses, in order to apply the stress reduction according to the following formulae:

$$\sigma_x = \left(\sigma_x^* - 0.3 \cdot \sigma_y^*\right) / 0.91$$

$$\sigma_y = \left(\sigma_y^* - 0.3 \cdot \sigma_x^*\right) / 0.91$$

σ_x^*, σ_y^* = *stresses containing the Poisson-effect*

Where compressive stress fulfils the condition $\sigma_y^* < 0.3\sigma_x^*$, then $\sigma_y = 0$ and $\sigma_x = \sigma_x^*$

Where compressive stress fulfils the condition $\sigma_x^* < 0.3\sigma_y^*$, then $\sigma_x = 0$ and $\sigma_y = \sigma_y^*$

F_1 = correction factor for boundary condition at the longitudinal stiffeners according to Table 3.8.

Table 3.8 : Correction factor F_1

Stiffeners sniped at both ends	1.00
Guidance values[1] where both ends are effectively connected to adjacent structures	1.05 for flat bars 1.10 for bulb sections 1.20 for angle and tee-sections 1.30 for u-type sections[2] and girders of high rigidity
An average value of F_1 is to be used for plate panels having different edge stiffeners	
[1] Exact values may be determined by direct calculations [2] Higher value may be taken if it is verified by a buckling strength check of the partial plate field using non-linear FEA and deemed appropriate by IRS, but not greater than 2.0	

σ_e = reference stress, [N/mm²], taken equal to

$$= 0.9 \cdot E\left(\frac{t}{b}\right)^2$$

Ψ = edge stress ratio taken equal to

= σ_2/σ_1 where

σ_1 = maximum compressive stress

σ_2 = minimum compressive stress or tensile stress

S = safety factor (based on net scantling approach), taken equal to

= 1.25 for hatch covers when subjected to the vertical design weather load according to 1.3.1

= 1.10 for hatch covers when subjected to loads according to 1.3.3 to 1.3.5

λ = reference degree of slenderness, taken equal to:

$$= \sqrt{\frac{\sigma_F}{K \cdot \sigma_e}}$$

K = buckling factor according to Table 3.8.2.

3.8.1 Proof of top and lower hatch cover plating

Proof is to be provided that the following condition is complied with for the single plate field of longer dimension ‘a’ and shorter dimension ‘b’.

$$\left(\frac{|\sigma_x|\cdot S}{\kappa_x\cdot\sigma_F}\right)^{e1}+\left(\frac{|\sigma_y|\cdot S}{\kappa_y\cdot\sigma_F}\right)^{e2}-B\left(\frac{\sigma_x\cdot\sigma_y\cdot S^2}{\sigma_F^2}\right)+\left(\frac{|\tau|\cdot S\cdot\sqrt{3}}{\kappa_\tau\cdot\sigma_F}\right)^{e3}\le 1.0$$

The first two terms and the last term of the above condition shall not exceed 1,0.

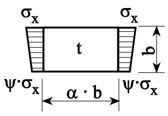
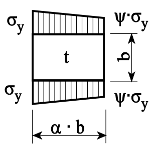
The reduction factors k_x, k_y and $k\tau$ are given in Table 3.8.2.

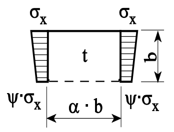
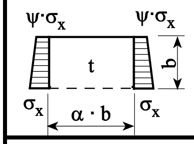
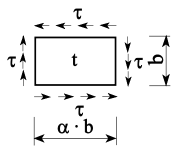
Where $\sigma_x \le 0$ (tensile stress), $k_x = 1.0$.

Where $\sigma y \le 0$ (tensile stress), $\kappa y = 1.0$.

The exponents e_1, e_2 and e_3 as well as the factor B are to be taken as given by Table 3.8.1.

Table 3.8.1 : Coefficients e_1, e_2, e_3 and factor B	
Exponents e_1 - e_3 and factor B	Plate panel
e_1	$1+\kappa_x^4$
e_2	$1+\kappa_y^4$
e_3	$1+\kappa_x\cdot\kappa_y\cdot\kappa_\tau^2$
B σ_x and σ_y positive (compressive stress)	$(\kappa_x\cdot\kappa_y)^5$
B σ_x or σ_y negative (tensive stress)	1

<table>
<tr><th colspan="5">Table 3.8.2 : Buckling and reduction factors for plane elementary plate panels</th></tr>
<tr><th>Buckling-Load Case</th><th>Edge stress ratio ψ</th><th>Aspect ratio $\alpha = a/b$</th><th>Buckling factor K</th><th>Reduction factor κ</th></tr>
<tr><td rowspan="3">1
</td><td>$1 \geq \psi \geq 0$</td><td rowspan="3">$\alpha \geq 1$</td><td>$K = \dfrac{8.4}{\psi + 1.1}$</td><td rowspan="3">$\kappa_x = 1$ for $\lambda \leq \lambda_c$
$\kappa_x = c\left(\dfrac{1}{\lambda} - \dfrac{0.22}{\lambda^2}\right)$ for $\lambda > \lambda_c$
$c = (1.25 - 0.12\psi) \leq 1.25$
$\lambda_c = \dfrac{c}{2}\left(1 + \sqrt{1 - \dfrac{0.88}{c}}\right)$</td></tr>
<tr><td>$0 > \psi > -1$</td><td>$K = 7.63 - \psi(6.26 - 10\psi)$</td></tr>
<tr><td>$\psi \leq -1$</td><td>$K = (1-\psi)^2 \cdot 5.975$</td></tr>
<tr><td rowspan="5">2
</td><td>$1 \geq \psi \geq 0$</td><td>$\alpha \geq 1$</td><td>$K = F_1\left(1 + \dfrac{1}{\alpha^2}\right)^2 \cdot \dfrac{2.1}{(\psi + 1.1)}$</td><td rowspan="5">$\kappa_y = c\left(\dfrac{1}{\lambda} - \dfrac{R + F^2(H-R)}{\lambda^2}\right)$
$c = (1.25 - 0.12\psi) \leq 1.25$
$R = \lambda\left(1 - \dfrac{\lambda}{c}\right)$ for $\lambda < \lambda_c$
$R = 0.22$ for $\lambda \geq \lambda_c$
$\lambda_c = \dfrac{c}{2}\left(1 + \sqrt{1 - \dfrac{0.88}{c}}\right)$
$F = \left(1 - \dfrac{\dfrac{K}{0.91} - 1}{\lambda_p^{\,2}}\right) \cdot c_1 \geq 0$
$\lambda_p^{\,2} = \lambda^2 - 0.5$ for $1 \leq \lambda_p^{\,2} \leq 3$
$c_1 = \left(1 - \dfrac{F_1}{\alpha}\right) \geq 0$
$H = \lambda - \dfrac{2\lambda}{c\left(T + \sqrt{T^2 - 4}\right)} \geq R$
$T = \lambda + \dfrac{14}{15\lambda} + \dfrac{1}{3}$</td></tr>
<tr><td rowspan="2">$0 > \psi > -1$</td><td>$1 \leq \alpha \leq 1{,}5$</td><td>$K = F_1\left[\left(1 + \dfrac{1}{\alpha^2}\right)^2 \cdot \dfrac{2{,}1(1+\psi)}{1.1} - \dfrac{\psi}{\alpha^2}(13.9 - 10\psi)\right]$</td></tr>
<tr><td>$\alpha > 1{,}5$</td><td>$K = F_1\left[\left(1 + \dfrac{1}{\alpha^2}\right)^2 \cdot \dfrac{2.1(1+\psi)}{1.1} - \dfrac{\psi}{\alpha^2} \cdot (5.87 + 1.87\alpha^2 + \dfrac{8.6}{\alpha^2} - 10\psi)\right]$</td></tr>
<tr><td rowspan="2">$\psi \leq -1$</td><td>$1 \leq \alpha \leq \dfrac{3(1-\psi)}{4}$</td><td>$K = F_1\left(\dfrac{1-\psi}{\alpha}\right)^2 \cdot 5.975$</td></tr>
<tr><td>$\alpha > \dfrac{3(1-\psi)}{4}$</td><td>$K = F_1\left[\left(\dfrac{1-\psi}{\alpha}\right)^2 \cdot 3.9675 + 0.5375\left(\dfrac{1-\psi}{\alpha}\right)^4 + 1.87\right]$</td></tr>
</table>

3 	$1 \ge \psi \ge 0$	$\alpha > 0$	$K = \dfrac{4\left(0.425 + \dfrac{1}{\alpha^2}\right)}{3\psi + 1}$	$\kappa_x = 1$ for $\lambda \le 0.7$ $\kappa_x = \dfrac{1}{\lambda^2 + 0{,}51}$ for $\lambda > 0.7$
	$0 > \psi \ge -1$		$K = 4\left(0.425 + \dfrac{1}{\alpha^2}\right)(1+\psi)$ $-5\psi(1-3.42\psi)$	
4 	$1 \ge \psi \ge -1$	$\alpha > 0$	$K = \left(0.425 + \dfrac{1}{\alpha^2}\right)\dfrac{3-\psi}{2}$	
5 	===		$K = K_\tau \cdot \sqrt{3}$	$\kappa_\tau = 1$ for $\lambda \le 0.84$ $\kappa_\tau = \dfrac{0{,}84}{\lambda}$ for $\lambda > 0.84$
		$\alpha \ge 1$	$K_\tau = \left[5.34 + \dfrac{4}{\alpha^2}\right]$	
		$0 < \alpha < 1$	$K_\tau = \left[4 + \dfrac{5.34}{\alpha^2}\right]$	
Explanations for boundary conditions			- - - - - plate edge free ——— plate edge simply supported	

3.8.2 Webs and flanges of primary supporting members

For non-stiffened webs and flanges of primary supporting members sufficient buckling strength as for the hatch cover top and lower plating is to be demonstrated according to 3.8.1.

3.8.3 Proof of partial and total fields of hatch covers

3.8.3.1 Longitudinal and transverse secondary stiffeners

It is to be demonstrated that the continuous longitudinal and transverse stiffeners of partial and total plate fields comply with the conditions set out in 3.8.3.3 through 3.8.3.4.
For u-type stiffeners, the proof of torsional buckling strength according to 3.8.3.4 can be omitted. Single-side welding is not permitted to use for secondary stiffeners except for u-stiffeners.

3.8.3.2 Effective width of top and lower hatch cover plating

For demonstration of buckling strength according to 3.8.3.3 through 3.8.3.4 the effective width of plating may be determined by the following formulae:

$b_m = \kappa_x \cdot b$ for longitudinal stiffeners

$a_m = \kappa_y \cdot a$ for transverse stiffeners

see also Fig.3.8.

The effective width of plating is not to be taken greater than the value e_m obtained from 3.7.1.

The effective width e'_m of stiffened flange plates of primary supporting members may be determined as follows:

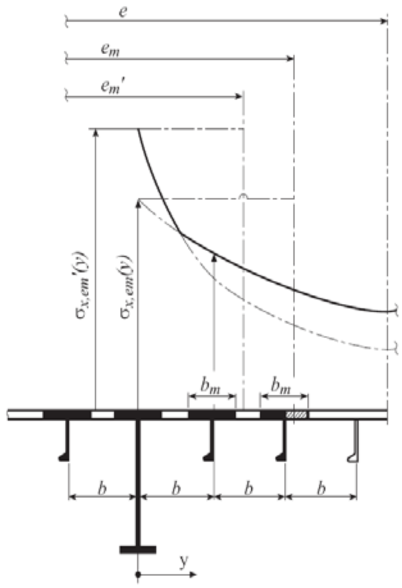


Fig. 3.8.3.2.1 : Stiffening parallel to web of primary supporting member

$b < e_m$

$e'_m = n \cdot b$

n = integer number of stiffener spacings b inside the effective breadth e_m according to 3.7.1

$= \text{int}\left(\frac{e_m}{b}\right)$

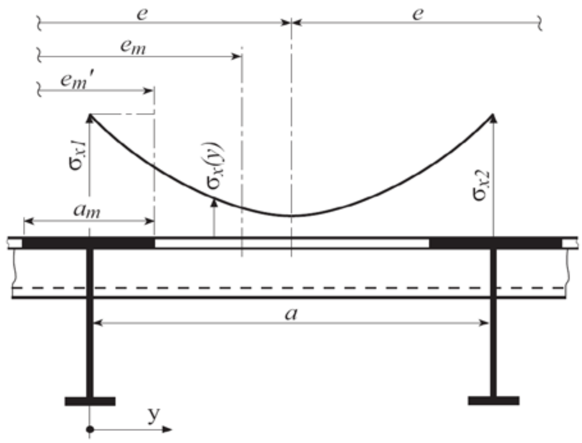


Fig. 3.8.3.2.2 : Stiffening perpendicular to web of primary supporting member

$a \geq e_m$

$e'_m = n \cdot a_m < e_m$

$n = 2{,}7 \cdot \frac{e_m}{a} \leq 1$

e = width of plating supported according to 3.7.1

For $b \geq e_m$ or $a < e_m$, respectively, b and a have to be exchanged.

a_m and b_m for flange plates are in general to be determined for $\psi = 1$.

Note:

Scantlings of plates and stiffeners are in general to be determined according to the maximum stresses $\sigma_x(y)$ at webs of primary supporting member and stiffeners, respectively. For stiffeners with spacing "b" under compression arranged parallel to primary supporting members no value less than "0.25" $\cdot \sigma_F$ shall be inserted for $\sigma_x(y{=}b)$.

The stress distribution between two primary supporting members can be obtained by the following formula:

$$\sigma_x(y) = \sigma_{x1} \cdot \left\{1 - \frac{y}{e}\left[3 + c_1 - 4 \cdot c_2 - 2\,\frac{y}{e}\left(1 + c_1 - 2\,c_2\right)\right]\right\}$$

$c_1 = \frac{\sigma_{x2}}{\sigma_{x1}} \qquad 0 \leq c_1 \leq 1$

$c_2 = \frac{1.5}{e} \cdot \left(e''_{m1} + e''_{m2}\right) - 0.5$

e''_{m1} = *proportionate effective breadth e_{m1} or proportionate effective width e'_{m1}*

		of primary supporting member 1 within the distance "e", as appropriate
e''_{m2}	=	*proportionate effective breadth* e_{m2} *or proportionate effective width* e'_{m2} *of primary supporting member 2 within the distance "e", as appropriate*
σ_{x1}, σ_{x2}	=	*normal stresses in flange plates of adjacent primary supporting member 1 and 2 with spacing e, based on cross-sectional properties considering the effective breadth or effective width, as appropriate*
y	=	*distance of considered location from primary supporting member 1*

Shear stress distribution in the flange plates may be assumed to vary linearly.

3.8.3.3 Lateral buckling of secondary stiffeners

$$\frac{\sigma_a + \sigma_b}{\sigma_F} S \leq 1$$

σ_a = uniformly distributed compressive stress, [N/mm^2] in the direction of the stiffener axis.

σ_a = σ_x for longitudinal stiffeners

σ_a = σ_y for transverse stiffeners

σ_b = bending stress, [N/mm^2], in the stiffener

$$= \frac{M_0 + M_1}{Z_{st} \cdot 10^3}$$

M_0 = bending moment, [Nmm], due to the deformation "w" of stiffener, taken equal to:

$$M_0 = F_{Ki} \frac{p_z \cdot w}{c_f - p_z} \quad \text{with } \left(c_f - p_z\right) > 0$$

M_1 = bending moment, [Nmm], due to the lateral load "p" equal to:

$$\mathrm{M}_1 = \frac{\mathrm{p}.10^3.\mathrm{b}.\mathrm{a}^2}{24\,\mathrm{x}10^3} \quad \text{for longitudinal stiffeners}$$

$$\mathrm{M}_1 = \frac{\mathrm{p}.10^3\,\mathrm{a(n/b)}^2}{\mathrm{c_s}.8\,\mathrm{x}10^3} \quad \text{for transverse stiffeners}$$

n is to be taken equal to 1 for ordinary transverse stiffeners.

p = lateral load [N/mm²]

F_{Ki} = ideal buckling force [N] of the stiffener

$$F_{Kix} = \frac{\pi^2}{a^2} \cdot E \cdot I_x \cdot 10^4$$ for longitudinal stiffeners

$$F_{Kiy} = \frac{\pi^2}{(n \cdot b)^2} \cdot E \cdot I_y \cdot 10^4$$ for transverse stiffeners

I_x, I_y = net moments of inertia, [cm^4], of the longitudinal or transverse stiffener including effective width of attached plating according to 3.8.3.2. I_x and I_y are to comply with the following criteria:

$$I_x \geq \frac{b \cdot t^3}{12 \cdot 10^4}$$

$$I_y \geq \frac{a \cdot t^3}{12 \cdot 10^4}$$

p_z = nominal lateral load, [N/mm^2], of the stiffener due to σ_x, σ_y and τ

(i) for longitudinal stiffeners

$$p_{zx} = \frac{t}{b}\left(\sigma_{xl}\left(\frac{\pi \cdot b}{a}\right)^2 + 2 \cdot c_y \cdot \sigma_y + \sqrt{2}\tau_1\right)$$

(ii) for transverse stiffeners

$$p_{zy} = \frac{t}{a}\left(2 \cdot c_x \cdot \sigma_{xl} + \sigma_y\left(\frac{\pi \cdot a}{n \cdot b}\right)^2\left(1 + \frac{A_y}{a \cdot t}\right) + \sqrt{2}\tau_1\right)$$

$$\sigma_{xl} = \sigma_x\left(1 + \frac{A_x}{b \cdot t}\right)$$

c_x, c_y = factor taking into account the stresses perpendicular to the stiffener's axis and distributed variable along the stiffener's length

$$= 0.5.(1 + \Psi)\ \text{for}\ 0 \leq \Psi \leq 1$$

$$= \frac{0.5}{1-\Psi} \quad \text{for}\,\Psi < 0$$

A_x, A_y = net sectional area, [mm²] of the longitudinal or transverse stiffener, respectively, without attached plating

$$\tau_1 = \left[\tau - t\sqrt{\sigma_F \cdot E\left(\frac{m_1}{a^2} + \frac{m_2}{b^2}\right)}\right] \geq 0$$

for longitudinal stiffeners:

$\frac{a}{b} \geq 2.0$: $m_1 = 1.47$ $m_2 = 0.49$

$\frac{a}{b} < 2.0$: $m_1 = 1.96$ $m_2 = 0.37$

for transverse stiffeners:

$\frac{a}{n.b} \geq 0.5$: $m_1 = 0.37$ $m_2 = \frac{1.96}{n^2}$

$\frac{a}{n.b} \geq 0.5$: $m_1 = 0.49$ $m_2 = \frac{1.47}{n^2}$

$$w = w_0 + w_1$$

w_o = assumed imperfection [mm]

$$w_{0x} \leq \min\left(\frac{a}{250}, \frac{b}{250}, 10\right)$$

- for longitudinal stiffeners

$$w_{0y} \leq \min\left(\frac{a}{250}, \frac{n \cdot b}{250}, 10\right)$$

- for transverse stiffeners

Note:

For stiffeners sniped at both ends w_O must not be taken less than the distance from the midpoint of plating to the neutral axis of the profile including effective width of plating.

w_1 = Deformation of stiffener, [mm], at midpoint of stiffener span due to lateral load "*p*".

In case of uniformly distributed load the following values for "w_1" may be used:

$$w_1 = \frac{p.b.a^4.10^3}{384.10^7.E.I_x}$$ for longitudinal stifeners

$$w_1 = \frac{5.\,a.p.(n\,.b)^4.10^3}{384.10^7.E.I_y.c_x^2}$$ for transverse stiffeners

c_f = elastic support provided by the stiffener, [N/mm²]

i) For longitudinal stiffeners:

$$c_{fx} = F_{Kix} \cdot \frac{\pi^2}{a^2} \cdot (1 + c_{px})$$

$$c_{px} = \frac{1}{\left\{1 + \frac{0.91.\left(\frac{12.10^4.I_x}{t^3.b} - 1\right)}{c_{xa}}\right\}}$$

$$c_{xa} = \left[\frac{a}{2b} + \frac{2b}{a}\right]^2 \quad \text{for} \quad a \geq 2b$$

$$c_{xa} = \left[1 + \left(\frac{a}{2b}\right)^2\right]^2 \quad \text{for} \quad a < 2b$$

ii) For transverse stiffeners:

$$c_{fy} = c_S \cdot F_{Kiy} \cdot \frac{\pi^2}{(n \cdot b)^2} \cdot (1 + c_{py})$$

$$c_{py} = \frac{1}{\left\{1 + \frac{0.91.\left(\frac{12.10^4.I_y}{t^3.a} - 1\right)}{c_{ya}}\right\}}$$

$$c_{ya} = \left[\frac{n \cdot b}{2a} + \frac{2a}{n \cdot b}\right]^2 \quad \text{for}$$

$n \cdot b \geq 2a$

$$c_{ya} = \left[1 + \left(\frac{n \cdot b}{2a}\right)^2\right]^2 \quad \text{for} \quad n \cdot b < 2a$$

c_S = factor accounting for the boundary conditions of the transverse stiffener
= 1.0 for simply supported stiffeners
= 2.0 for partially constrained stiffeners

Z_{St} = net section modulus of stiffener (longitudinal or transverse) [cm³] including effective width of plating according to 3.8.3.2.

If no lateral load "p" is acting the bending stress "σ_b" is to be calculated at the midpoint of the stiffener span for that fibre which results in the largest stress value. If a lateral load "p" is acting, the stress calculation is to be carried out for both fibres of the stiffener's cross sectional area (if necessary for the biaxial stress field at the plating side).

3.8.3.4 Torsional buckling of secondary stiffeners

3.8.3.4.1 Longitudinal secondary stiffeners

The longitudinal ordinary stiffeners are to comply with the following criteria:

$$\frac{\sigma_x \cdot S}{\kappa_T \cdot \sigma_F} \le 1.0$$

K_T = coefficient taken equal to:

$\kappa_T = 1.0$ for $\lambda_T \le 0.2$

$$\kappa_T = \frac{1}{\Phi + \sqrt{\Phi^2 - \lambda_T^2}} \quad \text{for } \lambda_T > 0.2$$

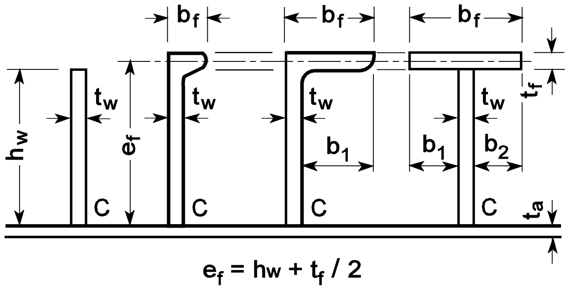
$$\Phi = 0.5\left(1 + 0.21(\lambda_T - 0.2) + \lambda_T^2\right)$$

λ_T = reference degree of slenderness taken equal to:

$$\lambda_T = \sqrt{\frac{\sigma_F}{\sigma_{KiT}}}$$

$$\sigma_{KiT} = \frac{E}{I_P}\left(\frac{\pi^2 \cdot I_\omega \cdot 10^2}{a^2}\varepsilon + 0.385 \cdot I_T\right),$$
[N/mm²]

For I_P, I_T, I_ω see Fig. 3.8.3.4.1 and Table 3.8.3.4.1.



e_f = hw + t_f / 2

Fig. 3.8.3.4.1 : Dimensions of stiffener

I_P = net polar moment of inertia of the stiffener, [cm⁴], related to the point C

I_T = net St. Venant's moment of inertia of the stiffener, [cm⁴]

I_ω = net sectorial moment of inertia of the stiffener, [cm⁶], related to the point C

ε = degree of fixation taken equal to:

$$\varepsilon = 1 + 10^{-3}\sqrt{\frac{a^4}{\frac{3}{4}\pi^4 \cdot I_\omega\left(\frac{b}{t^3} + \frac{4h_w}{3t_w^3}\right)}}$$

h_w = web height, [mm]

t_w = net web thickness, [mm]

b_f = flange breadth, [mm]

t_f = net flange thickness, [mm]

A_w = net web area equal to: $A_w = h_w \cdot t_w$

A_f = net flange area equal to: $A_f = b_f \cdot t_f$

$e_f = h_w + \frac{t_f}{2}$, [mm]

Table 3.8.3.4.1 : Moments of inertia

Section	I_P	I_T	I_ω
Flat bar	$\dfrac{h_w^3 \cdot t_w}{3 \cdot 10^4}$	$\dfrac{h_w \cdot t_w^3}{3 \cdot 10^4}\left(1 - 0.63\dfrac{t_w}{h_w}\right)$	$\dfrac{h_w^3 \cdot t_w^3}{36 \cdot 10^6}$
Sections with bulb or flange	$\left(\dfrac{A_w \cdot h_w^2}{3} + A_f \cdot e_f^2\right)10^{-4}$	$\dfrac{h_w \cdot t_w^3}{3 \cdot 10^4}\left(1 - 0.63\dfrac{t_w}{h_w}\right)$ + $\dfrac{b_f \cdot t_f^3}{3 \cdot 10^4}\left(1 - 0.63\dfrac{t_f}{b_f}\right)$	for bulb and angle sections: $\dfrac{A_f \cdot e_f^2 \cdot b_f^2}{12 \cdot 10^6}\left(\dfrac{A_f + 2.6A_W}{A_f + A_W}\right)$ for tee-sections: $\dfrac{b_f^3 \cdot t_f \cdot e_f^2}{12 \cdot 10^6}$

3.8.3.4.2 Transverse secondary stiffeners

For transverse secondary stiffeners loaded by compressive stresses and which are not supported by longitudinal stiffeners, sufficient torsional buckling strength is to be demonstrated analogously in accordance with 3.8.3.4.1.

3.9 Hatch covers with variable cross-section

Hatch covers with Z and I gradually reducing towards the ends of the span are to be designed so that the maximum bending stresses and deflections are not increased.

3.9.1 When the section shape is reduced towards the ends (See Fig. 3.9) the requirements of the section modulus Z and the moment of inertia I of the section in the middle uniform part are to be increased by the factors C_1 and C_2 respectively

where C_1 and C_2 are given by

$$C_1 = 1 + \frac{3.2\alpha - \beta - 0.8}{7\beta + 0.4}$$

$$C_2 = 1 + 8\alpha^3 \frac{1 - \delta}{0.2 + 3\sqrt{\delta}}$$

where,

$\alpha = l_1 / l_0$

$\beta = Z_1/Z_o$

$\delta = I_1/I_o$

I_o, Z_0 and I_1, Z_1 are the moment of inertia and section modulus at middle of span and at the ends respectively as shown in Fig.3.9.

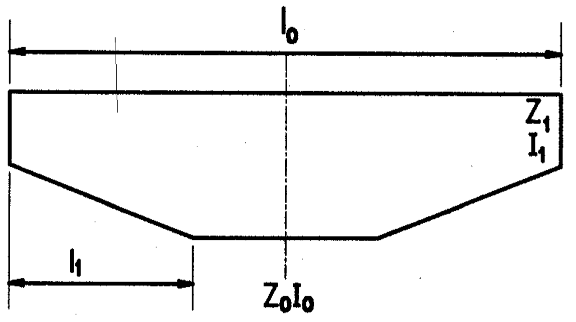


Fig.3.9 : Hatchcovers with variable cross-section

3.9.2 The net web area of the primary supporting members at any point is not to be less than:

$$A = 10\frac{\left(0.5 - \dfrac{x}{l}\right)}{\tau_a}.l\text{sp } [\text{cm}^2]$$

where,

τ_a = allowable shear stress

= 0.46 σ_F [N/mm^2]

x is the distance [m] from the end of the span to the section considered. The value of x is not to be taken more than 0.25*l*.

3.10 Wooden hatch covers

3.10.1 Wooden hatch covers are to have a finished thickness of not less than 60[mm] in association with an unsupported span of 1.5 [m] and of not less than 82 [mm] with 2 [m] unsupported span. The thickness for the intermediate span may be obtained by linear interpolation. Where the tween deck height exceeds 2.6 [m], the thickness of the wood hatch cover is to be increased at the rate of 16.5 per cent per metre of excess tween deck height.

3.10.2 The ends of all wooden hatch covers are to be protected by encircling with galvanized steel bands, about 65 [mm] wide and 3 [mm] thick, efficiently secured.

3.11 Portable hatch beams

3.11.1 The section modulus and the moment of inertia of the portable hatch beams stiffened at their upper and lower edges by continuous flat bars are to satisfy the requirements of 3.4 for pontoon hatch covers.

3.11.2 The ends of the web plates are to be doubled, or inserts fitted for at least 180 [mm] along the length of the web.

3.11.3 The beams which carry the ends of wood or steel hatch covers, a 50 [mm] vertical flat is to be arranged on the upper face plate. The width of bearing surface for hatch covers is to be not less than 65 [mm].

3.11.4 Carriers or sockets, or other suitable arrangements are to be provided as means of the efficient fitting and securing of portable hatch beams. The arrangements are to be of suitable construction and the width of the bearing surface is not to be less than 75 [mm].

3.11.5 Sliding hatch beams are to be provided with an efficient device for locking them in their correct fore and aft positions when the hatchway is closed.

3.12 Direct calculations

3.12.1 Hatchcovers of special construction and arrangement e.g. covers designed and constructed as a grillage, covers supported along more than two opposite edges and covers supporting other covers, may require submission of direct strength calculation taking into account the arrangement of stiffeners and the supporting members.

Section 4

Hatch Cover Securing Arrangement

4.1 General

4.1.1 The gaskets and the securing arrangements are to be designed for the expected relative movement between cover and coaming or special devices are to be fitted to restrict such movement.

4.1.2 Securing arrangements together with suitable gasketting material are to ensure weathertightness of the covers to the satisfaction of the surveyors. The arrangements are to be such as to ensure that the weathertightness can be maintained in any sea condition.

4.1.3 The gasket material is to be of satisfactory air, seawater and if necessary oil resistant quality. It is to be effectively secured along the edges of the cover in a manner as to ensure that the forces from the hatch covers or cargo stowed on top of the hatchcovers are transferred to the coaming or to the deck by direct contact. The sealing is to be achieved by relatively soft packing. The hatch coaming or steel parts on the adjacent covers in contact with the packing are to be well rounded where necessary.

4.1.4 Dispensation of weather tight gaskets

For hatch covers of cargo holds solely for the transport of containers, upon request by the owners and subject to compliance with the following conditions the fitting of weather tight gaskets according to 4.1.2 and 4.1.3 may be dispensed with:

- The hatchway coamings is not to be less than 600 [mm] in height;

- The exposed deck on which the hatch covers are located is situated above a depth H(x) . H(x) is to be shown to comply with the following criteria:

  $H(x) \geq T_{fb} + f_b + h$ [m]

  T_{fb} = draught [m] corresponding to the assigned summer load line

  f_b = minimum required freeboard [m], determined in accordance with ICLL Reg.28 as modified by further regulations as applicable.

  $$h = 4.6\,\mathrm{m\,for}\,\frac{x}{L_L} \leq 0.75$$

  $$= 6.9\,\mathrm{m\,for}\,\frac{x}{L_L} \geq 0.75$$

- Labyrinths, gutter bars or equivalents are to be fitted proximate to the edges of each panel in way of the coamings. The clear profile of these opening is to be kept as small as possible.

- Where a hatch is covered by several hatch cover panels the clear openings of the gap in between the panels is not to be wider than 50 [mm].

- The labyrinths and gaps between hatch cover panels is to be considered as unprotected openings with respect to the requirements of intact and damage stability calculations.

- With regard to drainage of cargo holds and the necessary fire-fighting system reference is made to the sections P*iping Systems, Valves and Pumps and Fire Protection and Fire Extinguishing Equipment* of Pt.4, Ch.3, Pt.6 and Pt. 5, Ch.5, Sec. 2.2 of the Rules.

- Bilge alarms is be provided in each hold fitted with non-weathertight covers.

- Furthermore, Chapter 3 of IMO MSC/Circ. 1087 is to be referred to concerning the stowage and segregation of containers containing dangerous goods.

4.1.5 Securing devices are to be of reliable construction and securely attached to the hatchway coamings, decks or covers. Individual securing devices on each cover are to have approximately the same stiffness characteristics.

4.1.6 A metallic contact is to be kept between the hatchcover and the hull to effect electrical earthing.

4.1.7 Where rod cleats are fitted, resilient washers or cushions are to be incorporated.

4.1.8 In case where hydraulic arrangement is provided for securing the cleats, the system is to remain mechanically locked in closed position in the event of a failure of the hydraulic system.

4.1.9 Materials used in the manufacturer of stoppers or securing devices including welding electrodes are to be in accordance with relevant requirements given in Part 2.

4.2 Portable steel covers - tarpaulins and battening devices

4.2.1 At least two layers of tarpaulins in good condition are to be provided for each hatchway in position 1 and 2. The tarpaulins are to be free from jute, and are to be waterproof and of ample strength. The minimum mass of the material before treatment is to be 0.65 [kg/m^2] if the material is to be tarred, 0.60 [kg/m^2] if it is to be chemically dressed and 0.55 [kg/m^2] if to be dressed with black oil. A certificate to this effect is to be supplied by the makers of the tarpaulins. Special consideration will be given to the synthetic materials for the tarpaulins.

4.2.2 Cleats are to be of an approved pattern, at least 65 [mm] wide, with edges so rounded as to minimize damage to the wedges, and are to be spaced not more than 600 [mm] from centre to centre; the first and last cleats along each side or end being not more than 150 [mm] from the hatch corners. Cleats are to be so set as to fit the taper of the wedges.

4.2.3 Battens and wedges are to be efficient and in good condition. Wedges are to be of tough wood, generally not more than 200 [mm] in length and 50 [mm] in width. They should have a taper of not more than 1 in 6 and should not be less than 13 [mm] thick at the point.

4.2.4 For all hatchways in positions 1 and 2, steel bars or other equivalent means are to be provided in order to efficiently and independently secure each section of hatch covers after the tarpaulins are battened down. Hatch covers of more than 1.5 [m] in length are to be secured by at least two such securing devices. Where hatchway covers extend over intermediate supports, steel bars or their equivalent are to be fitted at each end of each section of the covers. At all other hatchways in exposed position on weather decks, ring bolts or other fittings suitable for lashings are to be provided.

Acceptable equivalent means to steel bars are to consist of devices and materials which will provide strength and stiffness equivalent to that of steel. Steel wire ropes cannot be regarded as satisfactory equivalent means. Care is to be taken that tarpaulins are adequately protected from the possibility of damage arising from the usage of securing devices which do not provide a flat bearing surface.

4.3 Securing devices

4.3.1 General

Securing devices between cover and coaming and at cross-joints are to be installed to provide weathertightness. Sufficient packing line pressure is to be maintained.

Securing devices must be appropriate to bridge displacements between cover and coaming due to hull deformations.

Securing devices are to be of reliable construction and effectively attached to the hatchway coamings, decks or covers. Individual securing devices on each cover are to have approximately the same stiffness characteristics.

Sufficient number of securing devices is to be provided at each side of the hatch cover considering the requirements of 3.6.2. This applies also to hatch covers consisting of several parts.

The materials of stoppers, securing devices and their weldings are to be to the satisfaction of IRS. Specifications of the materials are to be shown in the drawings of the hatch covers.

4.3.2 Rod cleats

Where rod cleats are fitted, resilient washers or cushions are to be incorporated.

4.3.3 Hydraulic cleats

Where hydraulic cleating is adopted, a positive means is to be provided so that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

4.3.4 Cross-sectional area of the securing devices

The gross cross-sectional area [cm^2] of the securing devices is not to be less than:

$$A = 0.28 \cdot q \cdot s_{SD} \cdot k_l$$

q = packing line pressure [N/mm], minimum 5 [N/mm]

s_{SD} = spacing between securing devices [m], not to be taken less than 2 [m]

$k_l = \left(\frac{235}{\sigma_F}\right)^e$, σ_F is the minimum yield strength of the material [N/mm^2], but is not to be taken greater than 0,7 σ_m where σ_m is the tensile strength of the material [N/mm^2].

e = 0.75 for $\sigma_F > 235$ [N/mm^2]
= 1.00 for $\sigma_F \leq 235$ [N/mm^2]

Rods or bolts are to have a gross diameter not less than 19 mm for hatchways exceeding 5 [m²] in area.

Securing devices of special design in which significant bending or shear stresses occur may be designed as anti-lifting devices according to 4.3.5. As load, the packing line pressure q multiplied by the spacing between securing devices s_{SD} is to be applied.

4.3.5 Anti lifting devices

The securing devices of hatch covers, on which cargo is to be lashed, are to be designed for the lifting forces resulting from loads according to 1.3.4, refer Fig.4.3.5. Unsymmetrical loadings, which may occur in practice, are to be considered. Under these loadings the equivalent stress in the securing devices is not to exceed:

$$\sigma_V = \frac{150}{k_l} \text{ [N/mm²]}$$

Note:
The partial load case given in Table 1.3.4.4 may not cover all unsymmetrical loadings, critical for hatch cover lifting.

Omission of anti-lifting devices will be specially considered.

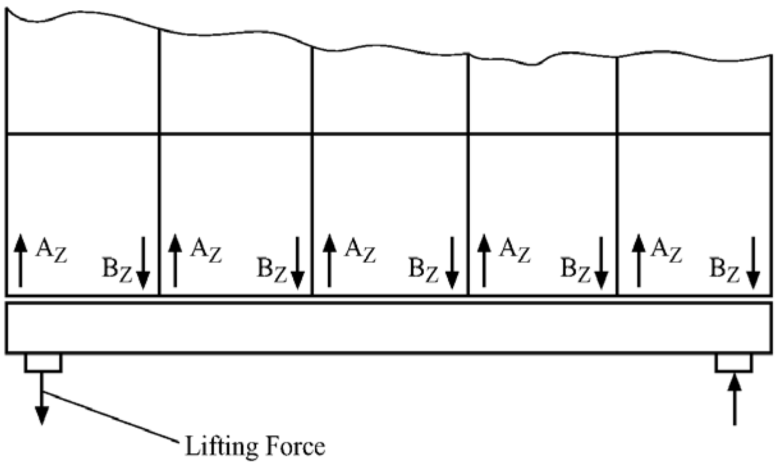


Fig. 4.3.5 : Lifting forces at a hatch cover

4.4 Hatch cover supports, stoppers and supporting structures

4.4.1 Horizontal mass forces

For the design of the hatch cover supports the horizontal mass forces $F_h = m \cdot a$ are to be calculated with the following accelerations:

$a_X = 0.2 \cdot g$ in longitudinal direction

$a_Y = 0.5 \cdot g$ in transverse direction

m = Sum of mass of cargo lashed on the hatch cover and mass of hatch cover

The accelerations in longitudinal direction and in transverse direction do not need to be considered as acting simultaneously.

4.4.2 Hatch cover supports

For the transmission of the support forces resulting from the load cases specified in 1.3 and of the horizontal mass forces specified in 4.4.1, supports are to be provided which are to be designed such that the nominal surface pressures in general do not exceed the following values:

$p_{n\max} = d \cdot p_n$ [N/mm^2]

d = 3.75 – 0.015 L

$d_{\max}$ = 3.0

$d_{\min}$ = 1.0 in general

= 2.0 for partial loading conditions, see 1.3.4.1

P_n = permissible nominal surface pressure [N/mm^2] as per Table 4.4.2.

For metallic supporting surfaces not subjected to relative displacements, the nominal surface pressure applies:

$p_{n\max} = 3 \cdot p_n$ [N/mm²]

Note:

When the maker of vertical hatch cover support material can provide proof that the material is sufficient for the increased surface pressure, not only statically but under dynamic conditions including relative motion for adequate number of cycles, permissible nominal surface pressure may be relaxed at the discretion of IRS. However, realistic long term distribution of spectra for vertical loads and relative horizontal motion should be assumed and agreed with IRS.

Drawings of the supports are to be submitted. In the drawings of supports the permitted maximum pressure given by the material manufacturer must be specified.

Where large relative displacements of the supporting surfaces are to be expected, the use of material having low wear and frictional properties is recommended.

Table 4.4.2 : Permissible nominal surface pressure p_n		
Support material	p_n [N/mm²] when loaded by	
	Vertical force	Horizontal force (on stoppers)
Hull structural steel	25	40
Hardened steel	35	50
Plastic materials on steel	50	–

The substructures of the supports must be of such a design, that a uniform pressure distribution is achieved.

Irrespective of the arrangement of stoppers, the supports must be able to transmit the following force P_h in the longitudinal and transverse direction:

$$P_h = \mu \cdot \frac{P_V}{\sqrt{d}}$$

P_V = vertical supporting force

μ = frictional coefficient
= 0.5 in general

For non-metallic, low-friction support materials on steel, the friction coefficient may be reduced but not to be less than 0.35 and to the satisfaction of IRS.

Supports as well as the adjacent structures and substructures are to be designed such that the permissible stresses according to 3.3.1 are not exceeded.

For substructures and adjacent structures of supports subjected to horizontal forces P_h, a fatigue strength analysis is to be carried out.

4.4.3 Hatch cover stoppers

Hatch covers shall be sufficiently secured against horizontal shifting. Stoppers are to be provided for hatch covers on which cargo is carried.

The greater of the loads resulting from 1.3.2 and 4.4.1 is to be applied for the dimensioning of the stoppers and their substructures.
The permissible stress in stoppers and their substructures, in the cover, and of the coamings is to be determined according to 3.3.1. In addition, the provisions in 4.4.2 are to be observed.

Section 5

Side Shell Doors and Stern Doors

5.1 General

5.1.1 These rules give requirements for the arrangement, strength and securing of side shell doors, abaft the collision bulkhead, and stern doors leading into enclosed spaces.

5.1.2 Stern doors for passenger vessels are to be situated above the freeboard deck. Stern doors for Ro-Ro cargo ships and side shell doors may be either below or above the freeboard deck.

5.1.3 Side shell doors and stern doors are to be so fitted as to ensure tightness and structural integrity commensurate with their location and the surrounding structure.

The sill of any side shell door is, in general, not to be below a line drawn parallel to the freeboard deck at side, with its lowest point 230 [mm] above the uppermost loadline.

5.1.4 Where the sill of any side shell door is below the line specified in 5.1.3 satisfactory additional features are to be fitted to maintain the watertight integrity. Fitting of a second door of equivalent strength and watertightness is one acceptable arrangement. Leakage detection device should be provided in the compartment between the two doors. Further, drainage of this compartment to the bilges controlled by an easily accessible screw down valve, should be arranged.

5.1.5 Doors should preferably open outwards.

5.1.6 Definitions

Securing device : a device used to keep the door closed by preventing it from rotating about its hinges or about pivotted attachments to the ship.

Supporting devices : a device used to transmit external or internal loads from the door to a securing device and from the securing device to the ship's structure, or a device other than a securing device, such as a hinge, stopper or other fixed device, that transmits loads from the door to the ship's structure.

Locking device : a device that locks a securing device in the closed position.

5.2 Design loads

5.2.1 The design forces, [N] considered for the scantlings of primary members, securing and supporting devices of side shell doors and stern doors are to be not less than:

i) Design forces for securing or supporting devices of doors opening inwards:

- external force : $F_e = AP_e\ 10^6 + F_p$
- internal force : $F_i = F_o + 10\ W$

ii) Design forces for securing or supporting devices of doors opening outwards:

- external force : $F_e = AP_e\ 10^6$
- internal force : $F_i = F_o + 10\ W + F_p$

iii) Design forces for primary members:

- external force : $F_e = AP_e\ 10^6$
- internal force : $F_i = F_o + 10\ W$

whichever is the greater,

where,

A = area [m^2] of the door opening

W = mass of the door [kg]

F_p = total packing force [N]. Packing line pressure is normally not to be taken less than 5 [N/mm]

F_o = the greater of F_c and 5000 A [N]

F_c = accidental force, [N] due to loose cargo etc., to be uniformly distributed over the area A and not to be taken less than 300000 [N]. For small doors such as bunker doors and pilot doors, the value of F_c may be appropriately reduced. However, the value of F_c may be taken as zero, provided an additional structure such as an inner ramp is fitted, which is capable of protecting the door from accidental forces due to loose cargoes.

P_e = external design pressure [N/mm^2] determined at the centre of gravity of the door opening and not taken less than the following:

a) $P_e = R_s\ k_s\ (C_w - 0.8\ h_o)\ .\ 10^{-3}$ [N/mm^2]

where,

R_s, k_s, C_w are as given in 3.2.1.

h_o = vertical distance [m] from the summer load waterline to the load point under consideration.

b) $P_e = 0.01\ (T_1 - Z_G) + 0.025$ [N/mm^2] for $Z_G < T_1$, and

0.025 [N/mm^2] for $Z_G > T_1$

where,

Z_G = height of the centre of area of the door [m] above the baseline, and

T_1 = draught [m] at the highest subdivision loadline.

Moreover, for stern doors of ships fitted with bow doors, P_e is not to be taken less than:

$P_e = 0.6\ \lambda\ C_H\ (0.8 + 0.6L^{0.5})^2\ .\ 10^{-3}$ [N/mm^2]

where,

λ = coefficient depending on the area where the ship is intended to be operated:

λ = 1 for sea going ships,

λ = 0.8 for ships operated in coastal waters,

λ = 0.5 for ships operated in sheltered waters.

C_H = 0.0125 L for L < 80 [m]
= 1 for $L \geq 80$ [m]

L = ship's length [m] but need not be taken greater than 200 [m].

5.3 Strength criteria

5.3.1 Scantlings of the primary members, securing and supporting devices of side shell doors and stern doors are to be determined considering simply supported end connections and the design loads defined in 5.2. The following permissible stresses are not to be exceeded:

shear stress : $\tau = \frac{80}{\mathrm{k}}$ [N/mm^2]

bending stress : $\sigma = \frac{120}{\mathrm{k}}$ [N/mm^2]

equivalent stress :

$$\sigma_c = \sqrt{\sigma^2 + 3\tau^2} = \frac{150}{\mathrm{k}} \text{ [N/mm}^2\text{]}$$

where k, the material factor, is not to be taken less than 0.72 unless a direct strength analysis with regard to relevant modes of failures is carried out.

5.3.2 The buckling strength of primary members is to be verified as being adequate.

5.3.3 For steel to steel bearings in securing and supporting devices, the nominal bearing pressure calculated by dividing the design force by the projected bearing area is not to exceed 0.8, where is the yield stress of the bearing material. For other bearing materials, the permissible bearing pressure is to be determined according to the manufacturer's specification.

5.3.4 The arrangement of securing and supporting devices is to be such that threaded bolts do not carry support forces. The maximum tension in way of threads of bolts not carrying support forces is not to exceed 125/k [N/mm^2].

5.4 Scantlings

5.4.1 The strength of side shell doors and stern doors is to be commensurate with that of the surrounding structure.

5.4.2 Side shell doors and stern doors are to be adequately stiffened and means are to be provided to prevent any lateral or vertical movement of the doors when closed. Adequate strength is to be provided in the connections of the lifting/manoeuvring arms and hinges to the door structure and to the ship's structure.

5.4.3 Where doors also serve as vehicle ramps, the design of the hinges should take into account the ship's angle of trim and heel which may result in uneven loading on the hinges.

5.4.4 Shell door openings are to have well-rounded corners and adequate compensation is to be arranged with web frames at sides and stringers or equivalent above and below.

5.4.5 The thickness of the door plating is not to be less than the required thickness for the side shell plating, using the door stiffener spacing, and not less than the minimum required thickness of shell plating as per Ch.8, Sec.4.1.

Where doors serve as vehicle ramps, the plating thickness is to be not less than required for vehicle decks.

5.4.6 The section modulus of secondary horizontal or vertical stiffeners is not to be less than that required for side framing as per Ch.8, Sec.4.3.2 and 4.3.5.

Where doors serve as vehicle ramps, the stiffener scantlings are not to be less than required for vehicle decks.

5.4.7 The secondary stiffeners are to be supported by primary members constituting the main stiffening of the door.

5.4.8 The primary members and the hull structure in way are to have sufficient stiffness to ensure structural integrity of the boundary of the door.

5.4.9 Scantlings of the primary members are to be based on direct strength calculations in association with the design forces given in 5.2 and permissible stresses given in 5.3.1.

5.5 Securing and supporting of doors

5.5.1 Side shell doors and stern doors are to be fitted with adequate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure. The hull supporting structure in way of the doors is to be suitable for the same design loads and design stresses as the securing and supporting devices.

Where packing is required, the packing material is to be of a comparatively soft type and the supporting forces are to be carried by the steel structure only. Other types of packing may be specially considered.

Maximum design clearance between securing and supporting devices is not generally to exceed 3 [mm].

A means is to be provided for mechanically fixing the door in the open position.

5.5.2 Only the active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered to calculate the reaction forces acting on the devices. Small and/or flexible devices such as cleats intended to provide local compression of the packing material are not generally to be included in the calculations in 5.5.4. The number of securing and supporting devices are generally to be the minimum practical whilst taking into account the requirement for redundant provision given in 5.5.5 and the available space for adequate support in the hull structure.

5.5.3 Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the permissible stresses given in 5.3.1.

5.5.4 The distribution of the reaction forces acting on the securing devices and supporting devices may require direct calculations taking into account the flexibility of the hull structure and the actual position of the supports.

5.5.5 The arrangement of securing devices and supporting devices in way of these securing devices is to be designed with redundancy so that in the event of failure of any single securing or supporting device the remaining devices are capable to withstand the reaction forces without exceeding by more than 20 per cent the permissible stresses as given in 5.3.1.

5.5.6 All load transmitting elements in the design load path, from the door through securing and supporting devices into the ship's structure, including pins, support brackets, back-up brackets and welded connections, are to be to the same strength standard as required for the securing and supporting devices.

5.6 Securing and locking arrangement

5.6.1 Securing devices are to be simple to operate and easily accessible.

Securing devices are to be equipped with mechanical locking arrangement (self locking or separate arrangement), or are to be of the gravity type. The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

5.6.2 Doors which are located partly or totally below the freeboard deck with a clear opening area greater than 6 [m^2] are to be provided with an arrangement for remote control, from a position above the freeboard deck of:

- the closing and opening of the doors,
- associated securing and locking devices.

For doors which are required to be equipped with a remote control arrangement, indication of the open/closed position of the door and the securing and locking device is to be provided at the remote control stations. The operating panels for operation of doors are to be inaccessible to unauthorized persons. A notice plate, giving instructions to the effect that all securing devices are to be closed and locked before leaving harbour, is to be placed at each operating panel and is to be supplemented by warning indicator lights.

Alternative means of securing are to be provided for emergency use in case of failure of the power systems.

5.6.3 Where hydraulic securing devices are applied, the system is to be mechanically lockable in closed position. This means that in the event of loss of the hydraulic fluid, the securing devices remain locked.

The hydraulic system for securing and locking devices is to be isolated from other hydraulic circuits, when in closed position.

5.6.4 The requirements in 5.6.5 to 5.6.8 apply to doors in the boundary of special category spaces or ro-ro spaces, as defined in Pt.6, Ch.1, Sec.3, through which such spaces may be flooded.

For cargo ships, where no part of the door is below the uppermost waterline and the area of the door opening is not greater than 6 [m^2], the requirements of this section need not be applied.

5.6.5 Separate indicator lights and audible alarms are to be provided on the navigation bridge and on each operating panel to indicate that the doors are closed and that their securing and locking devices are properly positioned.

The indication panel is to be provided with a lamp test function. It shall not be possible to turn off the indicator light.

5.6.6 The indicator system is to be designed on the fail safe principle and is to indicate by visual alarms if the door is not fully closed and not fully locked and by audible alarms if securing devices become open or locking devices become unsecured. The power supply for the indicator system is to be independent of the power supply for operating the doors and is to be provided with a backup power supply from the emergency source of power or other secure power supply such as a UPS.

The sensors of the indicator system are to be protected from water, ice formation and mechanical damages.

The requirements for fail safe design principle are to be similar to those for bow doors as indicated in 6.7.4.

5.6.7 The indication panel on the navigation bridge is to be equipped with a mode selection function "harbour/sea voyage", so arranged that audible alarm is given if the vessel leaves harbour with side shell or stern doors not closed or with any of the securing devices not in the correct position.

5.6.8 For passenger ships, a water leakage detection system with audible alarm and CCTV surveillance is to be arranged to provide an indication to the navigation bridge and to the engine control room of any leakage through the doors.

For cargo ships, a water leakage detection system with audible alarm is to be arranged to provide an indication to the navigation bridge.

5.6.9 For ro-ro passenger ships, on international voyages, the special category spaces and ro-ro spaces are to be continuously patrolled or monitored by effective means, such as CCTV surveillance, so that any movement of vehicles in adverse weather conditions and unauthorized access by passengers thereto, can be detected whilst the ship is underway.

5.7 Operating and maintenance manual

5.7.1 An Operating and Maintenance Manual for the side shell and stern doors is to be provided onboard and contain necessary information indicated in 6.8.1, as applicable.

This Manual has to be submitted for approval.

5.7.2 Documented operating procedures for closing and securing side shell and stern doors are to be kept on board and posted at the appropriate places.

Section 6

Bow Doors and Inner Doors

6.1 General

6.1.1 These requirements cover the arrangement, strength and securing of bow doors and inner doors leading to a complete or long forward enclosed superstructure.

6.1.2 Two types of bow doors have been considered:

- Visor doors opened by rotating upwards and outwards about a horizontal axis through two or more hinges located near the top of the door and connected to the primary structure of the door by longitudinally arranged lifting arms;

- Side-opening doors opened either by rotating outwards about a vertical axis through two or more hinges located near the outboard edges or by horizontal translation by means of linking arms arranged with pivoted attachments to the door and the ship. It is anticipated that side-opening bow doors are arranged in pairs.

Other types of bow door will be specially considered in association with the applicable requirements of this section.

6.1.3 Bow doors are to be situated above the freeboard deck. A watertight recess in the freeboard deck located forward of the collision bulkhead and above the deepest waterline fitted for arrangement of ramps or other related mechanical devices may be regarded as a part of the freeboard deck for the purpose of this requirement.

6.1.4 An inner door is to be fitted. The inner door is to be part of the collision bulkhead. The inner door need not be fitted directly above the bulkhead below, provided it is located within the limits specified for the position of the collision bulkhead. A vehicle ramp may be arranged for this purpose, provided its position is within the limits. (See Ch.10, Sec.2.2.5). If this is not possible, a separate inner weathertight door is to be installed, as far as practicable within the limits specified for the position of the collision bulkhead.

6.1.5 Bow doors are to be so fitted as to ensure tightness consistent with operational conditions and to give effective protection to inner doors. Inner doors forming part of the collision bulkhead are to be weathertight over the full height of the cargo space and arranged with fixed sealing supports on the aft side of the doors.

6.1.6 Bow doors and inner doors are to be arranged so as to preclude the possibility of the bow door causing structural damage to the inner door or to the collision bulkhead in the case of damage to or detachment of the bow door. If this is not possible, a separate inner weathertight door is to be installed, as indicated in Sec.6.1.4.

6.1.7 The requirements for inner doors are based on the assumption that vehicles are effectively lashed and secured against movement in stowed position.

6.1.8 Definitions

Securing devices : a device used to keep the door closed by preventing it from rotating about its hinges

Supporting device : a device used to transmit external or internal loads from the door to a securing device and from the securing device to the ship's structure, or a device other than a securing device, such as a hinge, stopper or other fixed device, that transmits loads from the door to the ship's structure

Locking device : a device that locks a securing device in the closed position.

6.2 Design loads

6.2.1 The external sea pressure to be considered for the scantlings of primary members, securing and supporting devices of bow doors is to be taken as the greater of

a) $P_e = R_s\ k_s\ (C_w - 0.8/h_o) \times 10^{-3}$ [N/mm^2]

where,

R_s, k_s, C_w as given in 3.2.1.

h_o = vertical distance [m] from the summer load waterline to the load point under consideration.

b) $P_e = 2.75\ \lambda\ C_H\ (0.22 + 0.15 \tan\alpha) \times$

$(0.4V \sin\beta + 0.6\ L^{0.5})^2 \times 10^{-3}$ [N/mm^2]

where,

V = maximum service speed, in knots

L = ship's length, [m], but need not be taken greater than 200 [m]

λ = coefficient depending on the area where the ship is intended to be operated:

λ = 1 for seagoing ships,

λ = 0.8 for ships operated in coastal waters,

λ = 0.55 for ships operated in sheltered waters.

C_H = 0.0125 L for L < 80 [m]
=1 for $L \geq 80$ [m]

α = flare angle [deg] at the point to be considered, defined as the angle between a vertical line and the tangent to the side shell plating, measured in a vertical plane normal to the horizontal tangent to the shell plating;

β = entry angle [deg] at the point to be considered, defined as the angle between a longitudinal line parallel to the centreline and the tangent to the shell plating in a horizontal plane. (See also Fig.6.2.1 for α and β).

6.2.2 The design external forces, considered for the scantlings of securing and supporting devices of bow doors are not to be less than:

$F_x = P_e A_x\ 10^3$ [kN]

$F_y = P_e A_y\ 10^3$ [kN]

$F_z = P_e A_z\ 10^3$ [kN]

where,

A_x = area, [m^2], of the transverse-vertical projection (i.e. in y-z plane) of the door between the levels of the bottom of the door and the top of the door including the bulwark, where it is part of the door. Where the flare angle of the bulwark is at least 15° less than the flare angle of the adjacent shell plating, the bulwark portion of the door may be excluded from the projected area.

A_y = area, [m^2], of the longitudinal-vertical projection (i.e. in (x-z plane) of the door between the levels of the bottom of the door and the top of the door, including the bulwark, where it is part of the door. Where the flare angle of the bulwark is at least 15° less than the flare angle of the adjacent shell plating, the bulwark portion of the door may be excluded from the projected area.

l = length, [m], of the door at a height h/2 above the bottom of the door;

w = breadth, [m], of the door at a height h/2 above the bottom of the door;

P_e = external pressure, as given in 6.2.1 with flare angle and entry angle β measured at a location on the shell h/2 above the bottom of the door and l/2 aft of the intersection of the door with the stem.

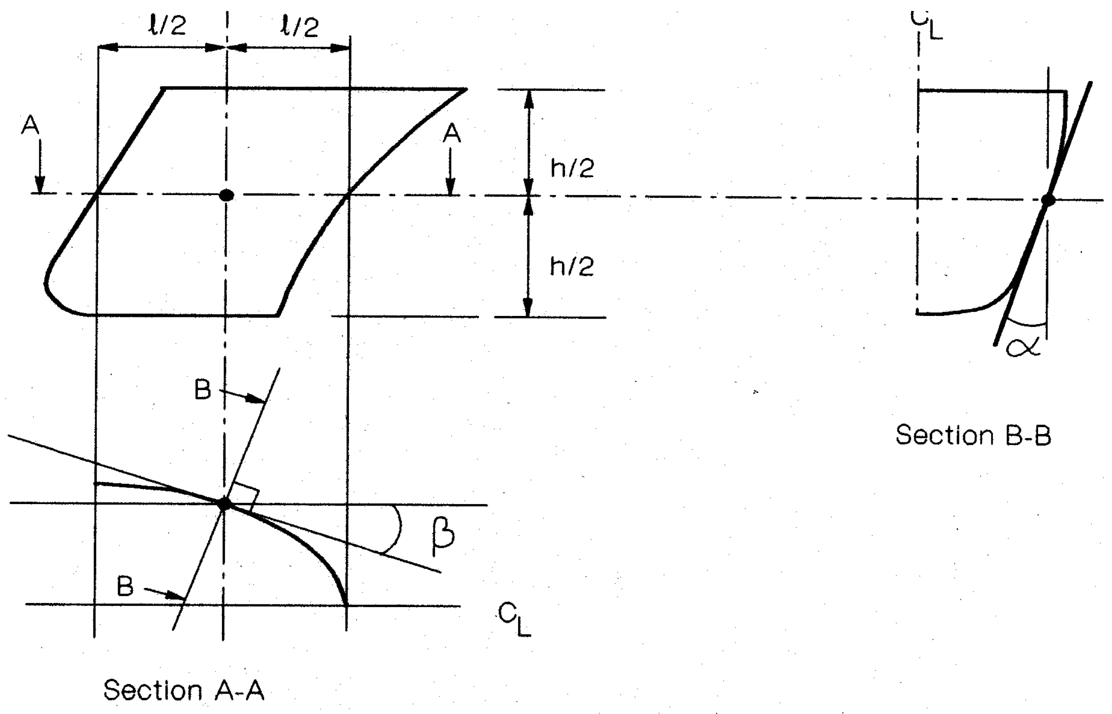


Fig.6.2.1 : Definition of α and β

A_z = area, [m^2], of the horizontal projection (i.e. in x-y plane) of the door between the bottom of the door and the top of the door, including the bulwark, where it is part of the door. Where the flare angle of the bulwark is at least 15° less than the flare angle of the adjacent shell plating, the bulwark portion of the door may be excluded from the projected area.

If the bulwark is flared inwards such that the horizontal projected area to the top of the bulwark is less than that to the upper deck, then the horizontal projected area to the upper deck is to be considered for the determination of A_z.

h = height, [m], of the door between the levels of the bottom of the door and the upper deck or between the bottom of the door and the top of the door, whichever is the lesser;

For bow doors, including bulwark, of unusual form or proportions, e.g. ships with a rounded nose and large stem angles, the areas and angles used for determination of the design values of external forces may require to be specially considered.

6.2.3 For visor doors the closing moment M_y under external loads, is to be taken as:

$$M_y = F_x\, a + 10 \,.\, c.\, W - F_z\, b \quad [\text{kN-m}]$$

where,

W = mass of the visor door, [t];

a = vertical distance, [m], from visor pivot to the centroid of the transverse vertical projected area of the visor door, as shown in Fig.6.2.3;

b = horizontal distance, [m], from visor pivot to the centroid of the horizontal projected area of the visor door, as shown in Fig.6.2.3;

c = horizontal distance, [m], from visor pivot to the centre of gravity of visor mass, as shown in Fig.6.2.3.

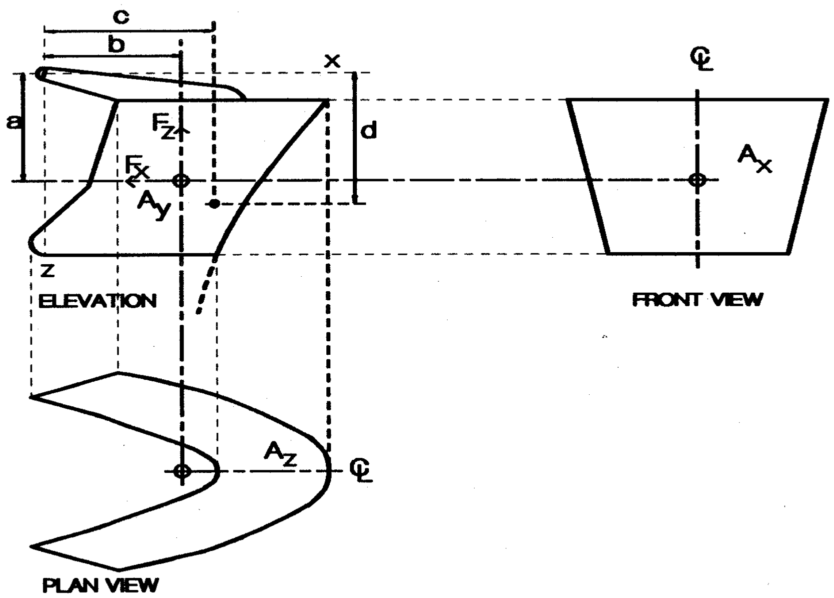


Fig.6.2.3 : Bow door of visor type

6.2.4 The design of lifting arms of a visor door and its supports is to take into account the static and dynamic forces applied during the lifting and lowering operations, and a minimum wind pressure of 0.0015 [N/mm^2].

6.2.5 The design external pressure, considered for the scantlings of primary members, securing and supporting devices and surrounding structure of inner doors is to be taken as the greater of the following:

a) $P_e = 0.45\ L \times 10^{-3}$ [N/mm^2]

b) $P_h = 0.01h$ [N/mm^2]

where,

h = the distance, [m], from the load point to the top of the cargo space.

L = ship's length [m], but need not be taken greater than 200 [m].

6.2.6 The design internal pressure P_b, considered for the scantlings of securing devices of inner doors is not to be less than:

$P_b = 0.025$ [N/mm^2]

6.3 Strength criteria

6.3.1 Scantlings of the primary members, securing and supporting devices of bow doors and inner doors are to be determined to withstand the design loads defined in 6.2, using the following permissible stresses:

bending stress:

$$\sigma = \frac{120}{\mathrm{k}}\ [\mathrm{N/mm^2}]$$

shear stress:

$$\tau = \frac{80}{\mathrm{k}}\ [\mathrm{N/mm^2}]$$

equivalent stress:

$$\sigma_c = \sqrt{\sigma^2 + 3\tau^2} = \frac{150}{\mathrm{k}}\ [\mathrm{N/mm^2}]$$

where, k, the material factor, is not to be taken less than 0.72, unless a direct fatigue analysis is carried out.

6.3.2 The buckling strength of primary members is to be in accordance with Ch.3, Sec.6.

6.3.3 For steel to steel bearings in securing and supporting devices, the nominal bearing pressure calculated by dividing the design force by the projected bearing area is not to exceed 0.8 times the yield stress of the bearing material. For other bearing materials, the bearing pressure is not to exceed the manufacturer's recommended value.

6.3.4 The arrangement of securing and supporting devices is to be such that threaded bolts do not carry support forces.

In bolts not carrying support forces, the maximum tensile stress in way of the bolt threads is not to exceed.

$$\tau = \frac{125}{\mathrm{k}}\ [\mathrm{N/mm^2}]$$

6.4 Scantlings of bow doors

6.4.1 General

The strength of bow doors is to be commensurate with that of the surrounding structure.

Bow doors are to be adequately stiffened and means are to be provided to prevent lateral or vertical movement of the doors when closed. For visor doors adequate strength for the opening and closing operations is to be provided in the connections of the lifting arms to the door structure and to the ship structure.

6.4.2 Plating and secondary stiffeners

The thickness of the bow door plating is not to be less than that required for the side shell plating as in Ch.8, Sec.4.1, using the bow door spacing and also not less than the minimum required thickness of fore end shell plating.

The section modulus of horizontal or vertical stiffeners is not to be less than that required for the end framing given in Ch.8, Sec.4.5 increased by 50 percent for simply supported ends.

The net sectional area of stiffener webs is not to be less than:

$$A = 0.05\ P_e s.l.\ \ [\mathrm{cm^2}]$$

6.4.3 Primary structure

The bow door secondary stiffeners are to be supported by primary members constituting the main stiffening of the door.

The primary members of the bow door and the hull structure in way, are to have sufficient stiffness to ensure integrity of the boundary support of the door.

Scantlings of the primary members are to be based on the external pressure given in 6.2.1 and permissible stresses given in 6.3. Supporting calculations for resultant stresses are to be submitted. Simple beam theory may be applied to determine the bending stresses. Members are to be considered to have simply supported end connections.

6.5 Scantlings of inner doors

6.5.1 General

Scantlings of the primary members of inner doors are to be based on the external pressure given in 6.2.5 and permissible stresses given in 6.3. Supporting calculations for resultant stresses are to be submitted.

Where inner doors also serve as vehicle ramps, the scantlings are not to be less than those required for vehicle decks as given in Ch.8, Sec.6.

Calculations to determine the distribution of forces acting on the securing and supporting devices are to take into account the flexibility of the structure and the actual position and stiffness of the supports and are to be submitted for approval.

6.6 Securing and supporting of bow doors

6.6.1 Bow doors are to be fitted with adequate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure. The hull supporting structure in way of the bow doors is to be strengthened for the loads and stresses arising from the securing and supporting devices. Where packing is required, the packing material is to be of a comparatively soft type, and the supporting forces are to be carried by the steel structure only. Other types of packing may be considered. Maximum design clearance between securing and supporting devices is not generally to exceed 3 [mm].

Means are to be provided for mechanically fixing the door in the open position.

6.6.2 Only the active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered while calculating the reaction forces acting on the devices. Small and/or flexible devices such as cleats intended to provide load compression of the packing material are not generally to be included in the calculations in 6.6.7. The number of securing and supporting devices are generally to be the minimum practical whilst taking into account the requirements for redundancy given in 6.6.7 and 6.6.8 and the space available for adequate support in the hull structure.

6.6.3 For visor doors opening outwards, the pivot arrangement is generally to be such that the visor is self closing under external loads, that is $M_y > 0$. Moreover, the closing moment M_y as given in 6.2.3 is to be not less than:

$M_{yo} = 10\ c\ W + 0.1\ (a^2 + b^2)^{0.5}\ (F_x^2 + F_z^2)^{0.5}$ [kN-m]

6.6.4 Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the permissible stresses given in 6.3.1.

6.6.5 For visor doors, the reaction forces applied on the effective securing and supporting devices assuming the door as a rigid body, are to be determined for the following combinations of external loads acting simultaneously together with the self weight of the door;

i) case 1 : F_x and F_z
ii) case 2 : $0.7F_y$ acting on each side separately together with $0.7F_x$ and $0.7F_z$

where F_x, F_y and F_z are determined as indicated in 6.2.2 and applied at the centroid of projected areas.

6.6.6 For side-opening doors, the reaction forces applied on the effective securing and supporting devices assuming the door as a rigid body, are to be determined for the following combination of external loads acting simultaneously together with the self weight of the door:

i) case 1 : F_x, F_y and F_z acting on both doors
ii) case 2 : $0.7F_x$ and $0.7F_z$ acting on both doors and $0.7F_y$ acting on each door separately,

where F_x, F_y and F_z are determined as indicated in 6.2.2 and applied at the centroid of projected areas.

6.6.7 The support forces as determined according to 6.2.2, 6.6.5 i) and 6.6.6 i) shall generally give rise to a zero moment about the transverse axis through the centroid of the area A_x. For visor doors, longitudinal reaction forces of pin and/or wedge supports at the door base contributing to this moment are not to be in the forward direction.

The arrangement of securing and supporting devices is to be designed with redundancy so that in the event of failure of any single securing or supporting device the remaining devices are capable to withstand the reaction forces without exceeding the permissible stresses given in 6.3.1, by more than 20 per cent .

6.6.8 For visor doors, two securing devices are to be provided at the lower part of the door, each capable of providing the full reaction force required to prevent opening of the door within the permissible stresses given in 6.3.1. The opening moment M_o, in kN-m, to be balanced by this reaction force, is not to be taken less than:

$M_o = 10\ W\ d + 5A_x\ a$

where,

d = vertical distance, [m], from the hinge axis to the centre of gravity of the door,
a = as defined in 6.2.3.

For visor doors, the securing and supporting devices excluding the hinges should be capable of resisting the vertical design force (F_z - 10W), in kN, within the permissible stresses given in 6.3.1.

6.6.9 For side-opening doors, thrust bearing has to be provided in way of girder ends at the closing of the two leaves to prevent one leaf to shift towards the other one under effect of unsymmetrical pressure (See Fig.6.6.9). Each part of the thrust bearing has to be kept secured on the other part by means of securing devices. Any other arrangement serving the same purpose may be proposed.

6.6.10 All load transmitting elements in the design load path, from door through securing and supporting devices into the ship structure, including pins, supporting brackets, back-up brackets and welded connections, are to be to the same strength standard as required for the securing end supporting devices.

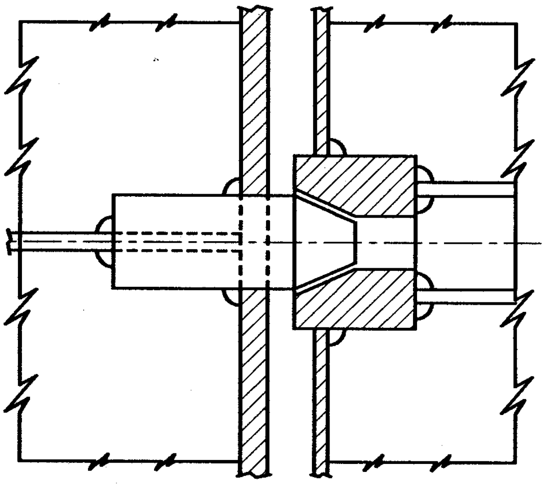


Fig.6.6.9 : Thrust bearing

6.7 Securing and locking arrangement

6.7.1 Securing devices are to be simple to operate and easily accessible.

Securing devices are to be equipped with mechanical locking arrangement (self locking or separate arrangement), or to be of the gravity type. The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

6.7.2 Bow doors and inner doors giving access to vehicle decks are to be provided with an arrangement for remote control of the following from a position above the freeboard deck:

- the closing and opening of the doors, and
- associated securing and locking devices for every door.

Indication of the open/closed position of every door and every securing and locking device is to be available at the remote control stations. The operating panels for operation of doors are to be inaccessible to unauthorized persons. A notice plate, giving instructions to the effect that all securing devices are to be closed and locked before leaving harbour, is to be placed at each operating panel and is to be supplemented by warning indicator lights.

Alternative means of securing are to be provided for emergency use in case of failure of the power systems.

6.7.3 Where hydraulic securing devices are applied, the system is to be mechanically lockable in closed position (i.e. in the event of loss of the hydraulic fluid, the securing devices are to remain locked).

The hydraulic system for securing and locking devices is to be isolated from other hydraulic circuits, when in closed position.

6.7.4 Separate indicator lights and audible alarms are to be provided on the navigation bridge and on the operating panel to show that the bow door and inner door are closed and that their securing and locking devices are properly positioned.

The indication panel is to be provided with a lamp test function. It shall not be possible to turn off the indicator light.

The indicator system is to be designed on the fail safe principle and is to show by visual alarms if the door is not fully closed and not fully locked and by audible alarms if securing devices become open or locking devices become unsecured. The power supply for the indicator system is to be independent of the power supply for operating the doors and provided with a back-up power supply from the emergency source of power or other secure power supply such as a UPS. The sensors of the indicator system are to be protected from water, ice formation and mechanical damages.

The indication panel on the navigation bridge is to be equipped with a mode selection function "harbour/sea voyage", so arranged that audible alarm is given on the navigating bridge if vessel leaves harbour with the bow door or inner door not closed and with any of the securing devices not in the correct position.

The indicator system is considered designed on the fail – safe principle when the following are satisfied:

1) The indication panel is provided with:

- a power failure alarm
- an earth failure alarm
- a lamp test
- separate indication for door closed, door locked, door not closed and door not locked.

2) Limit switches electrically closed when the door is closed (when more than one limit switch is provided they may be connected in series).

3) Limit switches electrically closed when securing arrangements are in place (when more

than one limit switch is provided they may be connected in series).

4) Two electrical circuits (may be provided in one multicore cable), one for the indication of door closed/not closed and the other for door locked / not locked.

5) In case of dislocation of limit switches, indication to show : not closed / not locked / securing arrangement not in place – as appropriate.

6.7.5 A water leakage detection system with audible alarm and CCTV surveillance is to be arranged to provide an indication to the navigation bridge and to the engine control room of leakage through the inner door.

Between the bow door and the inner door a CCTV surveillance system is to be fitted with a monitor on the navigation bridge and in the engine control room. The system is to monitor the position of doors and a sufficient number of their securing devices. Special consideration is to be given for lighting and contrasting colour of objects under surveillance.

6.7.6 A drainage system is to be arranged in the area between bow door and ramp, or where no ramp is fitted, between the bow door and inner door. The system is to be equipped with an audible alarm function to the navigation bridge for water level in these areas exceeding 0.5 [m] above the car deck level.

6.7.7 For ro-ro passenger ships on international voyages, the special category spaces and ro-ro spaces are to be continuously patrolled or monitored by effective means, such as CCTV surveillance, so that any movement of vehicles in adverse weather conditions or unauthorized access by passengers thereto, can be detected whilst the ship is underway.

6.8 Operating and maintenance manual

6.8.1 An Operating and Maintenance Manual for the bow door and inner door has to be provided on board and contain necessary information on:

- main particulars and design drawings
  special safety precautions;
  details of vessel;
  equipment and design loading (for ramps);
  key plan of equipment (doors and ramps);
  manufacturer's recommended testing for equipment;
  description of equipment:

    bow doors
    inner bow doors
    bow ramp/doors
    side doors
    stern doors
    central power pack
    bridge panel
    engine control room panel.

- service conditions: limiting heel and trim of ship for loading/unloading;
  limiting heel and trim for door operations;
  doors/ramps operating instructions;
  doors/ramps emergency operating instructions.

- Maintenance schedule and extent of maintenance;
  trouble shooting and acceptable clearances;
  manufacturer's maintenance procedures.

- register of inspections, including inspection of locking, securing and supporting devices, repairs and renewals.

This manual is to be submitted for approval.

6.8.2 Documented operating procedures for closing and securing the bow door and inner door are to be kept on board and posted at appropriate place.

Section 7

Miscellaneous Openings

7.1 Small openings on freeboard and superstructure decks

7.1.1 The number and size of hatchways and access openings are to be kept to the minimum, consistent with the satisfactory operation of the ship.

7.1.2 The height of coamings are to be in accordance with 2.1.1. Lower heights may be considered in relation to operational requirements and the nature of the spaces to which access is given. Such reduced coaming heights will also have to be approved by the concerned National Authorities.

7.1.3 The minimum coaming thickness is to be as given in 2.3.1 but need not exceed the rule minimum thickness of deck plating inside the line of openings for that position. The stiffening of coaming is to be appropriate to its length and height.

7.1.4 Hatchcovers are to be of steel and hinged in general. Weathertightness is to be maintained in all sea conditions. Where toggles are fitted, their diameter is to be not less than 16 [mm]. It is recommended that the spacing of toggles does not exceed 600 [mm] and the distance between hatch corner and adjacent toggle is not more than 300 [mm].

Hinges are not to be used as securing devices.

7.1.5 The thickness of the covers is to be not less than the minimum thickness of the deck, inside the line of opening at that location or (0.01 s) where 's' is the spacing of the stiffeners in [mm].

The hatch covers are to be adequately stiffened.

7.1.6 Escape hatches are to be capable of being operated from either side.

7.1.7 For hatch covers constructed of materials other than steel, the scantlings are to provide equivalent strength.

7.1.8 In addition to the requirements, in 7.1.1 to 7.1.6, small hatches on the exposed foredeck of vessels with L $\geq$ 80 [m] are to meet the requirements of 7.2.

7.2 Additional requirements for small hatches on the exposed fore deck

7.2.1 General

The requirements in 7.2.2 to 7.2.4 apply to small hatches on the exposed deck over the forward 0.25L on ships of L $\geq$ 80 [m], where the height of exposed deck above the summer load waterline in way of the hatch is less than 0.1L or 22 [m], whichever is less.

Small hatches in this context are hatches designed for access to spaces below the deck and capable of being closed weathertight and having an area of opening generally not exceeding 2.5 [m^2].

7.2.2 Strength

The plate thickness, stiffener arrangement and scantlings of the hatch covers are to be in accordance with Table 7.2.2 and Fig. 7.2.2. Stiffeners, where fitted, are to be aligned with the metal-to-metal contact points, required in 7.2.3 (see Fig.7.2.2). The primary stiffeners (shown by thick lines) are to be continuous. All stiffeners are to be welded to the inner edge stiffener indicated in Fig.7.2.3.

The upper edge of the hatchway coamings is to be suitably reinforced by a horizontal section, normally not more than 190 [mm] from the upper edge of the coamings.

For small hatch covers of circular or similar shape, the cover plate thickness and reinforcement would be specially considered.

7.2.3 Primary securing devices

7.2.3.1 Small hatches located on exposed fore deck are to be fitted with primary securing devices such that their hatch covers can be secured in place and weathertight by means of a mechanism employing any one of the following methods:

i) Butterfly nuts tightening onto forks (clamps),
ii) Quick acting cleats, or
iii) Central locking device.

Dogs (twist tightening handles) with wedges are not acceptable.

However, securing devices of hatches designed for emergency escape are to be of a quick-acting type (e.g. where one-action wheel handle is provided as central locking devices for latching / unlatching of hatch cover), operable from both sides of the hatch cover.

Butterfly nuts and quick acting cleats are not to be used for hatches.

7.2.3.2 The hatch cover is to be fitted with a gasket of elastic material. This is to be designed to allow a metal to metal contact at a designed compression and to prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged. The metal-to-metal contacts are to be arranged close to each securing device in accordance with Fig.7.2.2 and of sufficient capacity to withstand the bearing force.

7.2.3.3 For a primary securing method using butterfly nuts, the forks (clamps) are to be of robust design. They are to be designed to minimize the risk of butterfly nuts being dislodged while in use; by means of curving the forks upward, a raised surface on the free end, or a similar method. The plate thickness of unstiffened steel forks is not to be less than 16 [mm]. An example arrangement is shown in Fig.7.2.3. The primary securing method is to be designed and manufactured such that the designed compression pressure is achieved by one person without the need of any tools.

7.2.3.4 For small hatch covers located on the exposed deck forward of the fore-most cargo hatch, the hinges are to be fitted such that the predominant direction of green sea will cause the cover to close, which means that the hinges are normally to be located on the fore edge.

On small hatches located between the main hatches, for example between Nos.1 and 2, the hinges are to be placed on the fore edge or outboard edge, whichever is practicable for protection from green water in beam sea and bow quartering conditions.

Table 7.2.2 : Scantlings for small steel hatch covers on the fore deck

Nominal size [mm x mm]	Cover plate thickness [mm]	Primary stiffeners	Secondary stiffeners
		Flat bar [mm x mm]; number	
630 x 630	8	-	-
630 x 830	8	100 x 8 ; 1	-
830 x 630	8	100 x 8 ; 1	-
830 x 830	8	100 x 10 ; 1	-
1030 x 1030	8	120 x 12 ; 1	80 x 8 ; 2
1330 x 1330	8	150 x 12 ; 2	100 x10 ; 2

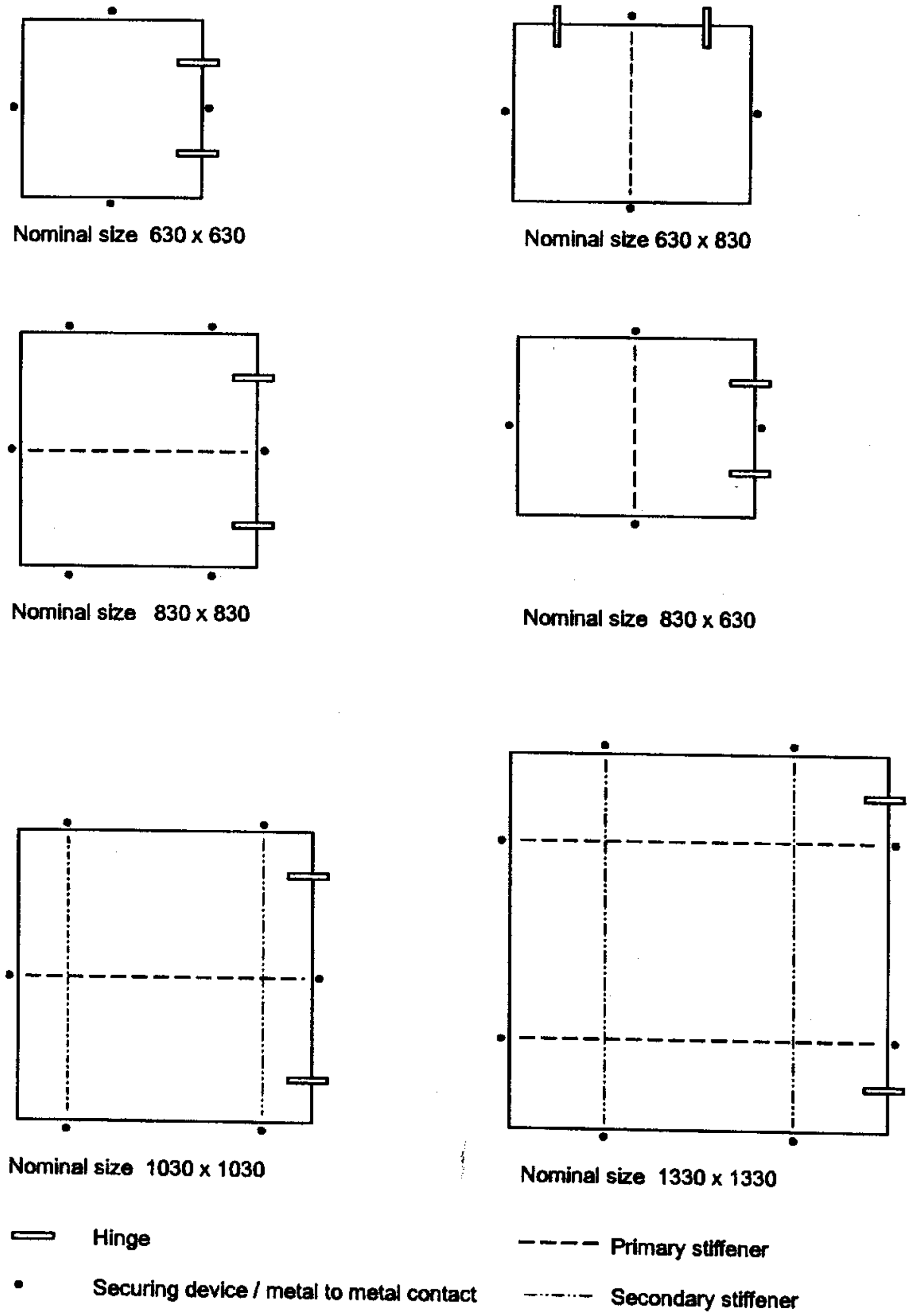
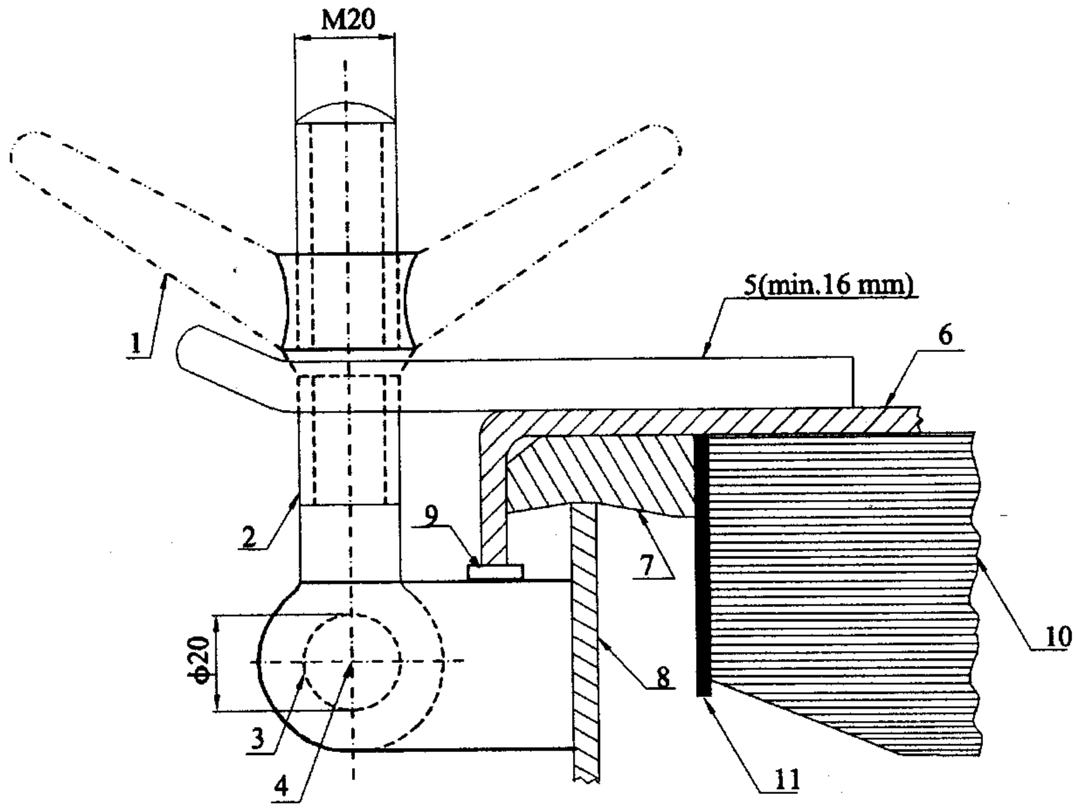


Fig.7.2.2 : Arrangement of stiffeners



1: butterfly nut
2: bolt
3: pin
4: center of pin
5: fork (clamp) plate
6: hatch cover
7: gasket
8: hatch coaming
9: bearing pad welded on the bracket of a toggle bolt for metal to metal contact
10: stiffener
11: inner edge stiffener

(Note: Dimensions in millimeters)

Fig.7.2.3 : Example of a primary securing method

7.2.4 Secondary securing device

Small hatches on the fore deck except those designed for emergency escapes are to be fitted with an independent secondary securing device e.g. by means of a sliding bolt, a hasp or a backing bar of slack fit, which is capable of keeping the hatch cover in place, even in the event that the primary securing device became loosened or dislodged. It is to be fitted on the side opposite to the hatch cover hinges.

7.3 Manholes and flush hatches

7.3.1 Manholes and flush scuttles on the decks fitted in Positions 1 and 2 or within superstructures other than enclosed superstructures, are to be closed by substantial covers capable of closing them weathertight. Unless secured by closely spaced bolts, the covers are to be permanently attached.

7.4 Hatchways within enclosed super-structure and tween decks

7.4.1 The requirements of 7.1 are to be complied with as and where applicable.

7.5 Companionways, doors and accesses on weather decks

7.5.1 Openings in freeboard decks, other than hatchways, machinery space openings, manholes and flush scuttles, are to be protected by an enclosed superstructure or by a deckhouse or companionway of equivalent strength and weathertightness to an enclosed superstructure, effectively secured to deck.

Any such openings:

a) in an exposed superstructure deck,
b) on top of a deckhouse on the freeboard deck and giving access to space below freeboard deck,
c) in an exposed position on the deck above a superstructure deck and giving access to space within that superstructure,

shall be protected by an efficient deckhouse or companionway as above. However in the case of c) it is considered that openings in the top of a deckhouse:

i) on a raised quarter deck or

ii) on a superstructure of less than standard height but having a height equal to or greater than standard quarter deck height

are to be provided with an acceptable means of closing but need not be protected by an efficient deckhouse or companionway provided the height of the deckhouse is at least the standard height of a superstructure.

The standard height of superstructures mentioned above are to be taken from Table 7.5.1.

Table 7.5.1

Freeboard Length L_L [m]	Standard height [m]	
	Raised quarter deck	Other super-structure
≤ 30	0.9	1.8
75	1.2	1.8
≥ 125	1.80	2.3
At intermediate length of the ship, standard height to be obtained by linear interpolation		

7.5.2 Steel doors or doors of other equivalent material are to be fitted to the following access openings in:

a) bulkheads at ends of enclosed superstructures.

b) deckhouses or companionways protecting openings leading to spaces below the freeboard deck, or to enclosed superstructures.

c) deckhouse on another deckhouse protecting an opening leading to a space below the freeboard deck.

The doors are to be permanently and strongly attached to the bulkhead and framed, stiffened and fitted so that the whole structure is of equivalent strength to the unpierced bulkhead and weathertight when closed. Any fixed lights in the doors are to be provided with hinged steel deadlights fitted internally. The doors are to be gasketed and secured weathertight by means of clamping devices or equivalent arrangements, permanently attached to the bulkhead or to the door. Doors are generally to open outward and are to be capable of being operated and secured from both sides.

7.5.3 Portable sills to be avoided. However in order to facilitate the loading/ unloading of heavy spare parts or similar items portable sills may be fitted on the following conditions:

a) They must be installed before the ship leaves port.

b) Sills are to be gasketed and fastened by closely spaced bolts.

c) Wherever the sills are replaced after removal, the weathertightness of the sills and the related doors must be verified by hose testing. The dates of removal, replacing and hose testing shall be recorded in the ship's, log book.

7.5.4 In locations other than those mentioned in Sec.7.5.2, doors may be of 50 [mm] thick hardwood or equivalent material and strength subject to any requirement of fire protection.

7.5.5 The height of doorway sills above the deck sheathing, if fitted, is to be at least

a) 600 [mm] in Position 1

b) 380 [mm] in Position 2.

7.5.6 Where access is provided to the deckhouse, bridge or a poop deck from the deck above as an alternative to the access from the freeboard deck, the height of sill into the deckhouse, bridge or poop may be 380 [mm].

7.5.7 The height of sills to doorways in a forecastle if protecting a companionway is to be 600 [mm], regardless of whether access is provided from above. If not protecting a companionway the sill height may be 380 [mm].

7.5.8 The height of door sills may be required to be increased on ships of Type 'A', Type 'B-100' or Type 'B-60' where this is shown to be necessary by the floatability calculations required by the ILLC 1966. The engine casing in such ships, when not protected by an outer structure will require two weathertight doors in series, with the sill height of the outer and inner door being not less than 600 [mm] and 230 [mm] respectively.

7.5.9 When the closing appliances of openings in superstructures and deckhouses do not comply with the requirements of 7.5.2, the openings on the interior deck are to be treated as if exposed to the weather deck.

7.6 Openings on engine and boiler casing

7.6.1 Machinery space openings in Position 1 or 2 are to have efficient closing appliances. The openings and coamings for fiddley, funnel and machinery space ventilators in the casing in those positions are to be provided with strong covers of steel or other equivalent material permanently attached in their proper positions and capable of being secured weathertight.

7.6.2 Doorways in the engine and boiler casings are to be arranged to provide the maximum protection of the space below.

7.6.3 Skylights are to be of substantial construction and secured firmly to the deck. For skylights in position 1 or 2 the coaming height is not to be less than that of the hatch coaming. Efficient means are to be provided for closing and securing the hinged scuttles, if any. The thickness of glasses in fixed or opening skylights is to be appropriate to their position and size as required for side scuttles. Glasses in any position are to be protected against mechanical damage, and where fitted in Positions 1 and 2 are to be fitted with deadlights or storm covers permanently attached.

7.6.4 Side scuttles in the engine casings are to be provided with fireproof glass.

7.7 Windows and side scuttles

7.7.1 Side scuttles and windows together with their glasses, deadlights and storm covers, if fitted, shall be of approved design and substantial construction in accordance with, or equivalent to, recognized national or international standards. Non-metallic frames are not acceptable.

'Deadlights', in accordance with recognised standards, are fitted to the inside of windows and side scuttles while 'storm covers', of comparable specifications to deadlights, are fitted to the outside of windows, where accessible, and may be hinged or portable.

7.7.2 Side scuttles are defined as being round or oval in shape and where the area of openings does not exceed 0.16 M^2.

Windows are defined as being rectangular in shape generally having a radius at each corner (depending on the window size in accordance with recognised national or international standards) and also those associated with round or oval shapes where the area of openings exceeds 0.16 M^2.

7.7.3 Side scuttles to the following spaces shall be fitted with efficient hinged inside deadlights:

a) spaces below the freeboard deck
b) spaces within the first tier of enclosed superstructures
c) first tier deckhouses on the freeboard deck protecting openings leading below
d) first tier deckhouses on the freeboard deck considered buoyant in stability calculations.

The deadlights shall be capable of being effectively closed and secured watertight if fitted below the freeboard deck and weathertight if fitted above.

7.7.4 Side scuttles shall not be fitted in such a position that their sills are below a line drawn parallel to the freeboard deck at side and having its lowest point 0.025B or 500 [mm], whichever is the greater distance, above the summer load line (or timber summer load line, if assigned).

7.7.5 Side scuttles shall be of the non-opening type in ships subject to damage stability regulations, if the calculations indicate that they would become immersed by any intermediate stage of flooding or the final equilibrium waterplane in any required damage case.

7.7.6 Windows shall not be fitted below the freeboard deck, in the first tier end bulkheads or sides of enclosed superstructures and in first tier deckhouses considered buoyant in the stability calculations or protecting openings leading below.

7.7.7 Side scuttles and windows at the side shell in the second tier, protecting direct access below or considered buoyant in the stability calculations, shall be provided with efficient hinged inside deadlights capable of being effectively closed and secured weathertight.

Side scuttles and windows set inboard from the side shell in the second tier, protecting direct access below to spaces listed in 7.6.3, shall be provided with either efficient hinged inside deadlights or, where they are accessible, permanently attached external storm covers of approved design and of substantial construction and capable of being effectively closed and secured weathertight.

7.7.8 Cabin bulkheads and doors in the second tier separating side scuttles and windows from a direct access leading below may be accepted in place of deadlights or storm covers fitted to the side scuttles and windows.

Deckhouses situated on a raised quarter deck or on the deck of a superstructure of less than standard height may be regarded as being in the second tier as far as the provision of deadlights is concerned, provided the height of the raised quarter deck or superstructure is equal to, or greater than, the standard quarter deck height.

7.7.9 Side scuttles and windows facing open or enclosed lifeboat and liferaft embarkation areas and below such areas in such a position that their failure during a fire would impede the launching of or embarkation into lifeboats or liferafts are to have adequate fire integrity.

End of Chapter

Chapter 13

Ventilators, Air Pipes and Discharges

Contents

Section 1

General

1.1 Scope

1.1.1 This Chapter applies to all ships and provides requirements for ventilators, air and sounding pipes and overboard discharges.

1.1.2 The requirements conform, where relevant, to those of the International Convention on Load Lines, 1966. Reference should also be made to any additional requirements of the National Authority of the country in which the ship is to be registered.

1.2 Definitions

1.2.1 The requirements of ventilators and air pipes are given with respect to two basic positions – Position 1 and Position 2 as defined in Ch.12, Sec.1.2.

1.3 Protection

1.3.1 In all cargo spaces and other areas where mechanical damage is likely, all air and sounding pipes, ventilators, scuppers and discharges, including their valves, controls and indicators, are to be well protected. This protection is to be of steel or other equivalent material.

1.4 Strength of attachments of fore deck fittings

1.4.1 The airpipes, ventilators and their closing devices fitted on ships of $L \geq 80$ [m] on exposed decks in the forward 0.25L are to satisfy the requirements given in 1.4.2 and 1.4.3 if the height of the exposed deck in way of the item is less than 0.1L or 22 [m] above the summer load waterline, whichever is the lesser:

However, these requirements need not be applied to cargo tank venting systems and inert gas systems of oil tankers, chemical carriers and liquefied gas carriers.

1.4.2 Design load

The green sea pressure ‘p’ acting on air pipes, ventilators and their closing appliances is to be taken as:

$$p = 0.5\, \rho\, V^2\, C_d\, C_s\, C_p \quad [kN/m^2]$$

where,

ρ = density of sea water = 1.025 t/m^3

V = velocity of water [m/sec] over the fore deck

= 13.5 for $d \leq 0.5d_1$

$= 13.5\sqrt{2(1-(d/d_1))}$

for $0.5d_1 < d < d_1$

d = distance [m] from summer load waterline to exposed deck

d_1 = 0.1L or 22[m] whichever is the lesser

C_d = shape coefficient

= 0.5 for pipes

= 1.3 for air pipe or ventilator heads in general

= 0.8 for an air pipe or ventilator head of cylindrical form with its axis in the vertical direction.

C_s = slamming coefficient = 3.2

C_p = protection coefficient:

= 0.7 for pipes and ventilator heads located immediately behind a breakwater or forecastle

= 1.0 elsewhere and immediately behind a bulwark.

Forces acting in the horizontal direction on the pipe and its closing device are to be calculated using pressure 'p' and the largest projected area of each component.

1.4.3 Strength criteria

a) Bending moments and stresses in air pipes and ventilator pipes are to be calculated at critical positions, such as at penetration pieces, weld or flange connections, and toes of supporting brackets. Bending stresses considering the net section (after deduction of 2.0 [mm] from the pipes thickness), irrespective of the corrosion protection provided are not to exceed 0.8 σ_y, where σ_y is the specified minimum upper yield stress or 0.2% proof stress of the steel at room temperature.

b) For standard ventilators of 900 [mm] height closed by heads of not more than the tabulated projected area, the applicable pipe thicknesses and bracket heights are specified in Table 1.4.3a). For standard air pipes of height 760 [mm] closed by heads of not more than the tabulated projected area, the applicable pipe thicknesses and bracket heights are specified in Table 1.4.3.b). For other configurations of air pipes and ventilators, loads according to clause 1.4.2 are to be applied and means of support determined in order to comply with the requirements of clause 1.4.3 a).

c) Where brackets are specified for supporting the air pipe or ventilator three or more radial brackets are to be fitted. These brackets are to have gross thickness of at least 8 [mm], minimum length 100 [mm] and height according to Table 1.4.3a) or Table 1.4.3b) as applicable but need not extend over the joint flange for the head. Bracket toes at the deck are to be suitably supported.

d) All component parts and connections of the air pipe or ventilator are to be capable of withstanding the green sea pressure 'p' given in 1.4.2.

e) Rotating type mushroom ventilator heads are unsuitable for application in the location defined in 1.4.1. Screw down type mushroom ventilators may be used in such locations.

Table 1.4.3a) : 900 mm [(a)] ventilator pipe thickness and bracket standards

Standard ventilator details			Required Height[(b)] of brackets mm]
Nominal pipe diameter [mm]	**Minimum fitted gross thickness [mm]**	**Maximum projected area of head [cm^2]**	
80A	6.3	-	460
100A	7.0	-	380
150A	8.5	-	300
200A	8.5	550	-
250A	8.5	880	-
300A	8.5	1200	-
350A	8.5	2000	-
400A	8.5	2700	-
450A	8.5	3300	-
500A	8.5	4000	-

Notes :

a) For other ventilator heights, the relevant requirements of 1.4.2 and 1.4.3 are to be applied.
b) Brackets need not extend over the joint flange for the head.

Table 1.4.3b) : 760 mm [(a)] air pipe thickness and bracket standard

Standard air pipe details			Required Height[(b)] of brackets [mm]
Nominal pipe diameter [mm]	**Minimum fitted gross thickness [mm]**	**Maximum projected area of head [cm^2]**	
65A	6.0	-	480
80A	6.3	-	460
100A	7.0	-	380
125A	7.8	-	300
150A	8.5	-	300
175A	8.5	-	300
200A	8.5	1900	300[(c)]
250A	8.5	2500	300[(c)]
300A	8.5	3200	300[(c)]
350A	8.5	3800	300[(c)]
400A	8.5	4500	300[(c)]

Notes :

a) For other air pipe heights, the relevant requirements of 1.4.2 and 1.4.3 are to be applied.

b) Brackets need not extend over the joint flange for the head.

c) Brackets need not be provided if the as fitted gross thickness of air pipes is not less than 10.5 [mm].

Section 2

Ventilators

2.1 General

2.1.1 Special care is to be taken in the design and positioning of ventilator openings and coamings, particularly in the region of the forward end of superstructures and other points of high stress. The deck plating in way of the coamings is to be efficiently stiffened.

2.1.2 Ventilators from deep tanks and tunnels passing through 'tween decks are to have scantlings suitable for withstanding the pressures to which they may be subjected, and are to be made watertight.

2.1.3 For the requirements of fire precautions on cargo and passenger ships, see Pt.6, Ch.2, Sec.2.

2.2 Coamings

2.2.1 The height of ventilator coamings exposed to the weather is to be not less than :

- 900 [mm] in position 1
- 760 [mm] in position 2

these heights being measured above deck sheathing where fitted. Particularly in exposed positions, the height of coamings may be required to be increased.

2.2.2 The height of ventilator coamings may be required to be increased on ships of Type 'A', Type 'B-100' and Type 'B-60' where this is shown to be necessary by the floatability criterion required by the International Convention on Load Lines, 1966.

2.2.3 The thickness of ventilator coamings is not to be less than 6.0 [mm] for ventilators upto 80 [mm] external diameter and 8.5 [mm] for ventilators of external diameters 165 [mm] and above; the thickness for intermediate diameters may be obtained by interpolation.

2.2.4 Where the height of the ventilator exceeds that required by 2.2.1 the thickness given in 2.2.3 may be gradually reduced, above the required minimum height, to a minimum of 6.0 [mm]. The ventilator is to be adequately stayed.

2.3 Closing appliances

2.3.1 All ventilator openings are to be provided with efficient weathertight closing appliances except where:-

(a) the height of the coaming is greater than 4.5 [m] in position 1, or

(b) the height of the coaming is greater than 2.3 [m] in position 2

in which case closing appliances need not be provided unless unusual features of design make it necessary.

The weathertight closing appliance for all ventilators in positions 1 and 2 are to be of steel or other equivalent materials. Wood plugs and canvas covers are not acceptable in these positions.

2.3.2 In general, ventilators which are necessary to continuously supply the machinery space and on demand, immediately supply the emergency generator room, should have coamings with sufficient heights specified in 2.3.1, without having to fit weathertight closing appliances.

However, where due to vessel size and arrangement this is not practicable, lesser heights for machinery space and emergency generator room ventilator coamings may be considered with provision of weathertight closing appliances in combination with other suitable arrangements to ensure an uninterrupted, adequate supply of ventilation to these spaces.

2.3.3 In ships where the load line length, L_L, is not more than 100 [m], the closing appliances are to be permanently attached to the ventilator coaming. Whereas in other ships, they may be conveniently stowed near the ventilator to which they are to be fitted.

2.3.4 Where, in ferries, ventilators are proposed to be led overboard in an enclosed 'tween deck' the closing arrangements are to be submitted for approval. If such ventilators are led overboard more than 4.5 [m] above the main vehicle deck, closing appliances may be omitted, provided that satisfactory baffles and drainage arrangements are provided, as in the case of air intakes or exhaust openings for machinery spaces, which may be arranged in the sides of the ship.

2.3.5 On offshore supply ships, to ensure satisfactory operation in all weather conditions, machinery space ventilation inlets and outlets are to be located in such positions that closing appliances will not be necessary.

Section 3

Air and Sounding Pipes

3.1 General

3.1.1 Air and sounding pipes are to comply with the requirements of Pt.4, Ch.2.

3.1.2 Striking plates of suitable thickness, or their equivalent, are to be fitted under all sounding pipes.

3.1.3 On offshore supply ships air pipes are to be situated clear of the cargo containment areas.

3.2 Height of air pipes

3.2.1 The height of air pipes from the upper surface of decks exposed to the weather, to the point where water may have access below is not normally to be less than :

- 760 [mm] on freeboard deck
- 450 [mm] on superstructure decks

these heights being measured above deck sheathing, where fitted. Air pipes with height exceeding 900 [mm] are to be additionally supported.

3.2.2 Lower heights may be approved in cases where these are essential for the working of the ship, provided that the design and arrangements are otherwise satisfactory. In such cases, efficient, permanently attached closing appliances of an approved automatic type will generally be required.

3.2.3 The height of air pipes may be required to be increased on ships of Type 'A', Type 'B-100' and Type 'B-60' where this is shown to be necessary by the floatability calculations required by the International Convention on Load Lines, 1966.

3.2.4 Air pipes are generally to be led to an exposed deck, but alternative arrangements will be considered in the case of ferries where such an arrangement is not practicable.

3.2.5 The thickness of the portion of the air pipe exposed to weather is not to be less than 6.0 [mm] upto 80 [mm] external diameter and 8.5 [mm] for 165 [mm] and above; the thickness for intermediate external diameters may be obtained by interpolation.

3.3 Closing appliances

3.3.1 All openings of air and sounding pipes are to be provided with permanently attached, satisfactory means of closing to prevent the free entry of water.

3.3.2 Air pipe closing devices are to be of an approved type and so designed that they withstand both ambient and working conditions and be suitable for use at inclinations upto and including 40^{o}.

3.3.3 Closing devices are to be of automatic type. Pressure-vacuum valves (P-V valves) may however, be accepted on tankers.

3.3.4 Air pipe closing devices are to be so constructed as to allow inspection of the closure and the inside of the casing as well as changing of the seals.

3.3.5 Efficient ball or float seating arrangements are to be provided for the closures. Bars, cage or other devices are to be provided to prevent the ball or float from contacting the inner chamber in its normal state and made in such a way that the ball or float is not damaged when subjected to water impact due to a tank being overfilled.

3.3.6 The clear area through an air pipe closing device is to be at least equal to the area of the inlet. Air pipe closing devices are to be self draining.

3.3.7 In the case of air pipe closing devices of the float type, suitable guides are to be provided to ensure unobstructed operation. The maximum allowable tolerances for wall thickness of ball floats is not to exceed 10% of the nominal thickness.

3.3.8 Casings of air pipe closing devices are to be of approved metallic materials adequately protected against corrosion. The inner and the outer chambers of an automatic air pipe head is to be of a minimum thickness of 6 [mm].

3.3.9 For galvanized steel air pipe heads, the zinc coating is to be applied by the hot method and the coating thickness is to be 70 to 100 microns.

For areas of the head susceptible to erosion (e.g. those parts directly subjected to ballast water impact when the tank is being pressed up, for example the inner chamber area above the air pipe, plus an overlap of 10° or more on either side) an additional harder coating such as aluminium bearing epoxy coating or equivalent, is to be applied over the zinc coating.

3.3.10 Closures and seats made of non-metallic materials are to be compatible with the media intended to be carried in the tank at temperatures between $-25^{o}C$ and $85^{o}C$ and sea water.

Section 4

Scuppers and Sanitary Discharges

4.1 General

4.1.1 Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

4.1.2 Scuppers draining weather decks and spaces within superstructures or deckhouses not fitted with efficient weathertight doors are to be led overboard.

4.1.3 Scuppers and discharges which drain spaces below the freeboard deck, or spaces within intact superstructures or deckhouses on the freeboard deck fitted with efficient weathertight doors, may be led to the bilges in the case of scuppers, or to suitable sanitary tanks in the case of sanitary discharges. Alternatively, they may be led overboard provided that the spaces drained are above the load waterline, and the pipes are fitted with efficient and accessible means of preventing water from passing inboard.

4.1.4 The drainage arrangements of enclosed 'tween deck spaces in ships with small freeboards are to be specially considered.

4.1.5 In the enclosed 'tween deck space on the main vehicle deck of a ferry, which is provided with a drencher fire extinguishing system, scuppers of not less than 150 [mm] diameter are to be provided port and starboard, spaced about 9,0 [m] apart. The capacity of the scuppers may be required to be increased, dependent on the discharge rate of the drencher system. The mouth of the scupper is to be protected by bars.

4.1.6 If a 'tween deck space on the main vehicle deck of a ferry is not totally enclosed, scuppers or freeing ports are to be provided consistent with the requirements of Ch.11.

4.1.7 The following will apply to drainage of enclosed cargo spaces on the bulkhead deck of passenger ships or on the freeboard deck of cargo ships:

i) Where the freeboard to the bulkhead deck or the freeboard deck, respectively, is such that the deck edge is immersed when the ship heels more than 5 [deg.] the drainage shall be by means of a sufficient number of scuppers of suitable size discharging directly overboard.

ii) Where the freeboard is such that the edge of the bulkhead deck or the edge of the freeboard deck, respectively, is immersed when the ship heels 5 [deg.] or less, the drainage shall be led to a suitable space of adequate capacity, having a high water level alarm and provided with suitable arrangements for discharge overboard.

4.1.8 For drainage arrangements of closed vehicle and ro-ro spaces and special category spaces, refer to Pt.6, Ch.7, Cl.3.6.1.4 and Cl.3.6.1.5.

4.1.9 Scuppers and discharge pipes should not normally pass through fuel oil or cargo oil tanks. Where scuppers and discharge pipes pass, unavoidably, through fuel oil or cargo oil tanks, and are led through the shell within the tanks, the thickness of the piping should be at least the same thickness as Rule shell plating in way, derived from the appropriate Chapters, but need not exceed 19 [mm].

Piping within tanks is to be tested in accordance with Pt.4, Ch.2 and Ch.3.

4.1.10 All piping is to be adequately supported.

4.2 Closing appliances

4.2.1 In general, each separate overboard discharge is to be fitted with a screw-down non-return valve capable of being operated from a position always accessible and above the freeboard deck. An indicator is to be fitted at the control position showing whether the valve is open or closed. (Fig.4.2.1).

It is considered that an acceptable equivalent to an automatic non-return valve with a positive means of closing from a position above the freeboard deck would be one automatic non-return valve and one sluice valve controlled from above the freeboard deck.

Where sanitary discharges and scuppers lead overboard through the shell in way of machinery spaces, the fitting to shell of a locally operated closing valve, together with non-return valve inboard, is considered to provide protection equivalent to above.

4.2.2 Where, in an enclosed 'tween deck space on the main vehicle deck of a ferry, a drencher fire extinguishing system is provided, such controls are to be operable from spaces above the main vehicle deck and to be protected from mechanical damage.

4.2.3 Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds $0{,}01L_L$ the discharge may be fitted with two automatic non-return valves without positive means of closing, instead of the screw-down non-return valve, provided that the inboard valve is always accessible for examination under service conditions i.e. the inboard valve should be above the level of the tropical load waterline. If this is not practicable, then, provided a locally controlled sluice valve is interposed between the two automatic non-return valves, the inboard valve need not be fitted above the LWL.

4.2.4 Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds $0{,}02L_L$, a single automatic non-return valve without positive means of closing may be fitted. See Fig.4.2.1.

4.2.5 Scuppers and discharge pipes originating at any level which penetrate the shell either more than 450 [mm] below the freeboard deck or less than 600 [mm] above the summer load waterline, are to be fitted with an automatic non-return valve at the shell. This valve, unless required by 4.1.3, may be omitted provided that the pipe is of heavy gauge thickness. However, the thickness need not exceed 12.5 [mm], unless greater thickness is required by 4.1.8.

4.2.6 If, in association with 4.1.8, a valve is required by 4.1.3, this valve should preferably be fitted as close as possible to the point of entry of the pipe into the tank. If fitted below the freeboard deck, the valve is to be capable of being controlled from an easily accessible position above the freeboard deck. Local control is also to be arranged, unless the valve is inaccessible. An indicator is to be fitted at the control position showing whether the valve is open or closed.

4.2.7 In a ship to which timber freeboards are assigned, the summer load waterline is to be regarded as that corresponding to the timber summer freeboard.

4.2.8 It is considered that requirements for non-return valves are applicable only to those discharges which remain open during the normal operation of a vessel. For discharges which must necessarily be closed at sea, such as gravity drains from topside ballast tanks, a single screw down valve operated from the deck is sufficient.

The inboard end of a gravity discharge which leads overboard from an enclosed superstructure or space is to be located above the waterline formed by a 5 degree heel, to port or starboard, at a draft corresponding to be assigned summer freeboard.

4.2.9 For garbage chutes an acceptable equivalent to the non-return valve with a positive means of closing from a position above the freeboard deck would be two gate valves controlled from the working deck of the chute. The lowest gate valve should, in addition, be controlled from a position above the freeboard deck. An interlock system is to be arranged between the two valves. The distance between the two gate valves is to be adequate to allow the smooth operation of the interlock system.

4.2.10 It is recommended that the inboard end of the garbage chute be located above the waterline formed by an 8.5 deg heel, to port or starboard, at a draft corresponding to the assigned summer freeboard, but not less than 1000[mm] above the summer waterline.

4.2.11 Where the inboard end of the garbage chute exceeds $0.01L_L$ above the summer waterline, valve control from the freeboard deck is not required, provided the inboard gate valve is always accessible under service conditions.

4.2.12 Alternatively, the upper gate valve may be replaced by a hinged weathertight cover at the inboard end of the chute together with a discharge flap which replaces the lower gate valve.
The cover and the flap are to be arranged with an interlock so that the discharge flap cannot be operated until the cover is closed.

The chute is to be constructed of material of substantial thickness (See Part 4, Chapter 3, Section 3.5) upto and including the cover.

4.2.13 The gate valve controls and/or hinged cover are to be clearly marked: “Keep closed when not in use”.

4.3 Materials for valves, fittings and pipes

4.3.1 All shell fittings and valves required by 4.2 are to be of steel, bronze or other approved ductile material; ordinary cast iron or similar material is not acceptable. Materials are to satisfy the requirements of Pt.2.

4.3.2 All these items, if made of steel or other approved material with low corrosion resistance, are to be suitably protected against wastage.

4.3.3 The lengths of pipe attached to the shell fittings, elbow pieces or valves are to be of galvanized steel or other equivalent approved material.

4.3.4 Where plastic pipes are used for sanitary discharges and scuppers, they are also subject to the requirement of Fig.4.2.1, and the valve at the shell is to be operated from outside the space in which the valve is located.

Where such plastic pipes are located below the summer waterline, the valve is to be operated from a position above freeboard deck.

The portion of discharge line from the shell to the first valve as well as shell fittings and valves shall be of steel; bronze or other approved ductile material.

The approval of plastic piping in any location will be subject to the consideration of strength and fire hazards involved with special reference to penetrations through bulkheads, decks or other significant compartment boundaries. Attention must be paid to valid fire technical regulations.

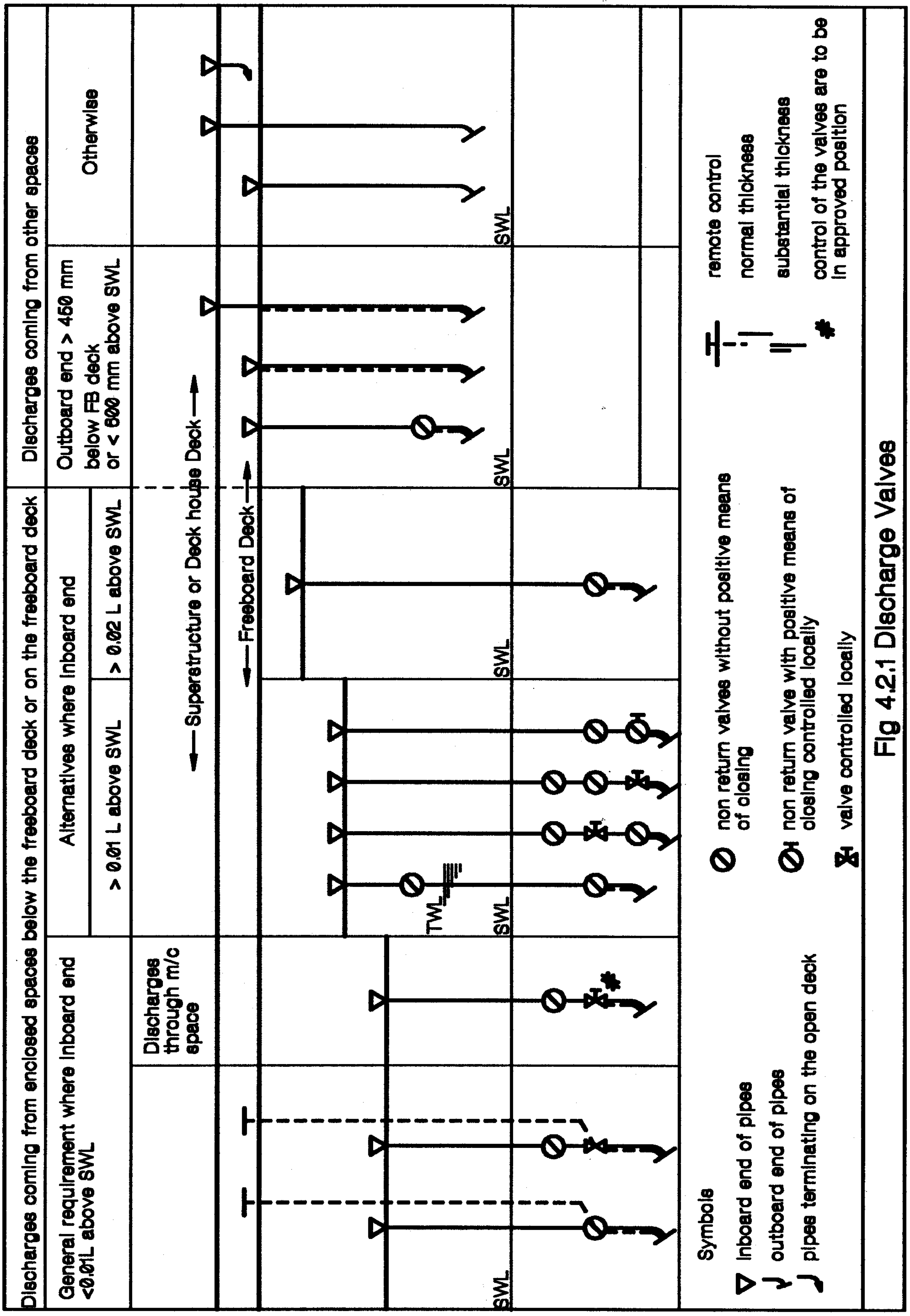


Fig 4.2.1 Discharge Valves

End of Chapter

Chapter 14

Rudders

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter apply to arrangement and scantlings of normal streamlined or plate rudders and their supporting structure. Rudders fitted with special features e.g. special profiles, fins, flaps, steering propellers etc. to increase the lift force will be specially considered.

1.1.2 IRS may accept alternatives to requirements given in this Chapter, provided they are deemed to be equivalent.

1.1.3 Direct analyses adopted to justify an alternative design are to take into consideration all relevant modes of failure, on a case by case basis. These failure modes may include, amongst others: yielding, fatigue, buckling and fracture. Possible damages caused by cavitation are also to be considered.

1.1.4 Lab tests, or full scale tests may be requested to validate the alternative design approach, if deemed necessary by IRS,

1.1.5 Additional requirements for various Ice Class notations are given in Pt.5, Ch.21.

1.2 Material

1.2.1 All materials used in the construction of the rudder are to be tested and approved in accordance with Pt.2.

1.2.2 Material grades for plates and sections for the rudder blade are to be selected as per Pt.3, Ch.2.

1.2.3 For rudder stocks, pintles, keys and bolts, the minimum yield stress is not to be less than 200 [N/mm^2]. For materials having yield stress differing from 235 [N/mm^2], material factor 'k' as determined below, is to be applied.

$$k = \left(\frac{235}{\sigma_y}\right)^e$$

with e = 0.75 for $\sigma_y > 235$ [N/mm^2]

= 1.0 for $\sigma_y \leq 235$ [N/mm^2]

σ_y = yield stress of the material used, but not to be taken greater than 0.7 σ_u or 450 [N/mm^2] whichever is smaller; where σ_u is the tensile strength [N/mm^2] of the material.

Where high strength steels are used for rudder stock, evaluation of stock deformations may be required, as large deformations can cause excessive edge pressures in way of bearings.

1.2.4 Bearing materials for bushings are to be stainless steel, bronze, white metal, synthetic material or lignum vitae. If stainless steel is proposed to be used for liners or bushes for the rudder stocks and pintles, the chemical composition is to be submitted for approval.

Hardness of the material of the bushing is to be at least 65 Brinell lower than that of the liner or the rudder stock or pintle.

Synthetic bush materials are to be of approved type. Arrangement is to be provided for adequate supply of sea-water to these bearings.

1.3 Testing

1.3.1 Bodies of the rudders are to be tested in accordance with the requirements given in Ch.18.

Section 2

Arrangement and Details

2.1 General

2.1.1 Various types of rudder arrangement are shown in Fig.2.1.1, other combinations of couplings and bearings may however be proposed.

2.1.2 Effective means are to be provided for supporting the weight of the rudder. Where the support is provided by a carrier bearing attached to the rudder head, the structure in way of the bearing is to be adequately strengthened. The plating under all rudder head bearings or rudder carriers is to be increased in thickness.

2.1.3 All rudder bearings are to be accessible for measuring wear without lifting or unshipping the rudder.

2.1.4 Satisfactory arrangement is to be provided to prevent water from entering the steering gear compartment and lubricant from being washed away from the rudder carrier. A seal or stuffing box is to be fitted above the deepest load water line for this purpose, however two separate seals or stuffing boxes are to be provided when the rudder carrier is below the deepest load water line.

2.1.5 Suitable arrangement is to be provided to prevent the rudder from lifting and accidental unshipping.

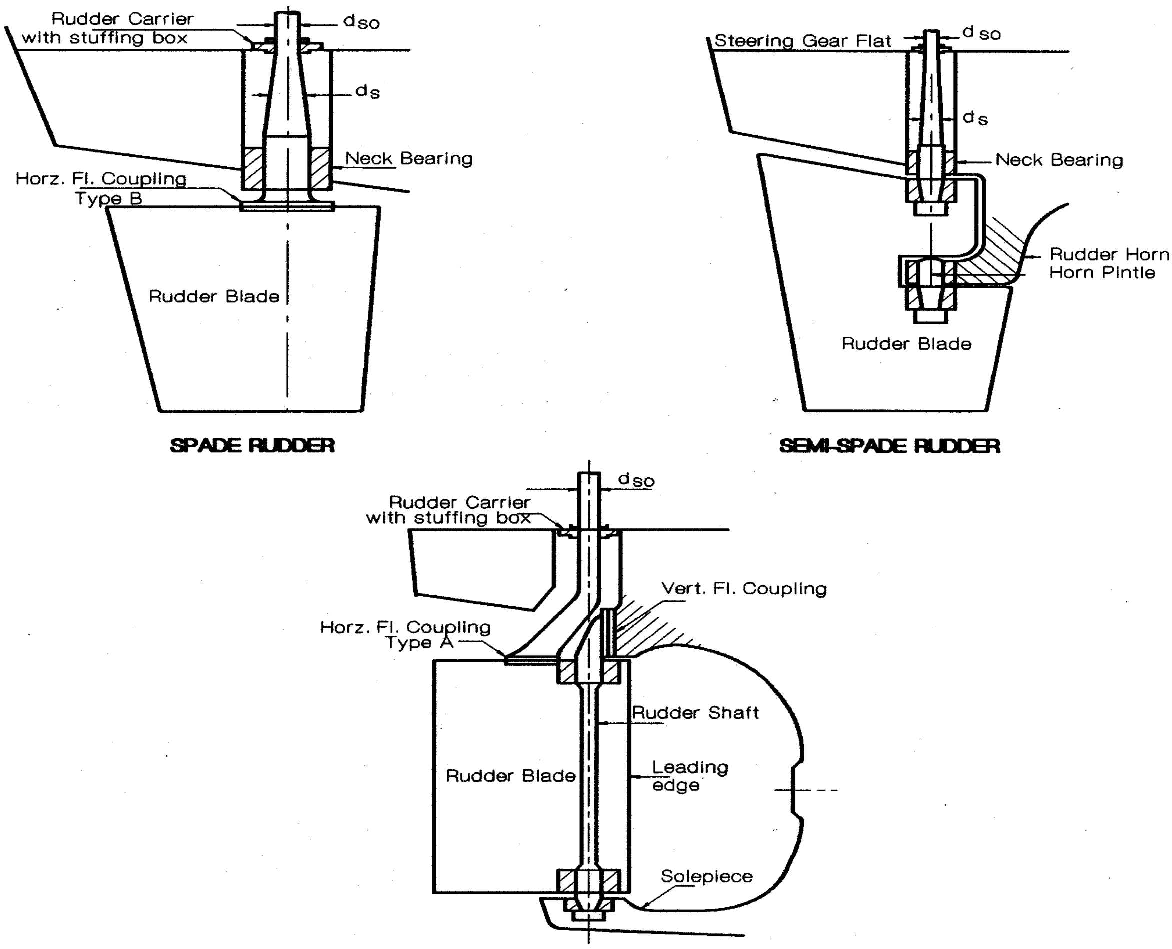


Fig.2.1.1 : Types of rudders

Section 3

Design Loads

3.1 Rudder force

3.1.1 The rudder force upon which rudder scantlings are to be based is to be determined from the following formula:

$F_r = 132 \,.\, K_1 \,.\, K_2 \,.\, K_3 \,.\, A \,.\, V^2$ [N]

where,

F_r = rudder force [N]

A = area of rudder blade [m^2]

V = maximum service speed (knots) with the ship on summer load waterline. When the speed is less than 10 knots, V is to be replaced by the expression.

$V_{min} = (V + 20)/3$

For astern condition, the maximum astern speed is to be used, but in no case less than:

$V_{astern} = 0.5V$

Where the service speed is obtained at lower power than the maximum continuous rating of the propelling machinery, the speed V to be used in the calculation is to be increased in proportion of $(\text{Power})^{1/3}$.

K_1 = factor based on the aspect ratio, λ of the rudder area;

$K_1 = (\lambda + 2)/3$; with λ not to be taken greater than 2.

$\lambda = b^2/A_t$; where b is the mean height of the rudder area [m] and At, the sum of rudder blade area and area of rudder post or rudder horn, if any, within the height b [m^2]

Mean breadth C [m] and mean height b [m] of rudder are calculated according to the co-ordinate system in Fig.3.1.1.

K_2 = Factor depending on type of the rudder and the rudder profile as per Table 3.1.1.

K_3 = 0.80 for rudders outside the propeller jet

= 1.15 for rudders behind a fixed propeller nozzle

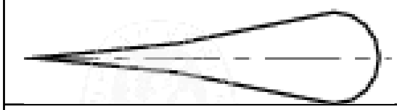
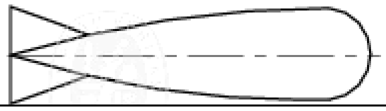
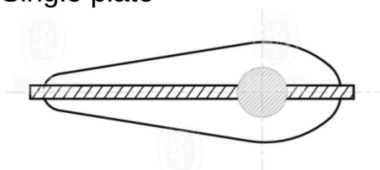
= 1.0 otherwise.

As per Fig, 3.1.1,

$C = \frac{x_2+x_3-x_1}{2}$; Mean Breadth of Rudder

$b = \frac{z_3+z_4-z_2}{2}$; Mean Height of Rudder

Table 3.1.1

Profile Type	K_2	
	Ahead condition	**Astern condition**
NACA-00 series Göttingen 	1.10	0.80
Flat side 	1.10	0.90
Hollow 	1.35	0.90
Fish tail 	1.40	0.80
Single plate 	1.00	1.00
Mixed profiles (e.g. HSVA)	1.21	0.90

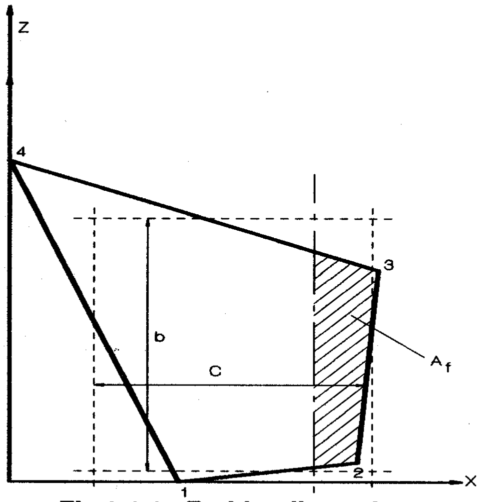


Fig.3.1.1 : Rudder dimensions

3.2 Rudder torque

3.2.1 The rudder torque on regular shaped rudders in both the ahead and astern conditions of travel is to be calculated as follows:

$$Q_r = F_r \cdot r \text{ [N-m]};$$

where,

$r = x_c - f$ [m]; but not to be taken less than 0.1C.

x_c = the distance of the point of application of the design force F_r from the leading edge

= 0.33 C in ahead condition

= 0.66 C in astern condition.

C = Mean breadth of rudder area [m] See Fig.3.1.1.

$f = C \cdot A_f/A$ where A_f is the portion of the rudder blade area situated ahead of the centre line of the rudder stock.

3.2.2 In case of rudder blades with stepped contours / semi-spade rudders, the total rudder torque is to be obtained as follows:

$$Q_r = \Sigma Q_{ri} \quad \text{for } i = 1,2,3,.....$$

where,

$Q_{ri} = F_{ri} \cdot r_i$; individual torque component from each part A_i of the total rudder area. See Fig.3.2.2.

$F_{ri} = F_r \cdot A_i/A$

$r_i = x_{ci} - f_i$; but not to be taken less than 0.1 C_i.

where,

$f_i = C_i \cdot A_{if}/A_i$

x_{ci}, f_i, A_{if} and C_i are to be taken as x_c, f, A_f and C as in 3.2.1 for each discrete part except that for those rudder parts immediately aft of rudder horn x_{ci} is to be taken as $0.25C_i$ and $0.55C_i$ in ahead and astern conditions respectively.

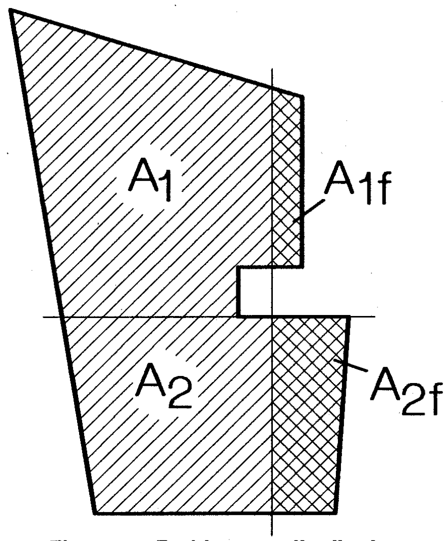


Fig.3.2.2 : Rudder area distribution

3.3 Rudder Strength Calculations

3.3.1 The rudder force and resulting rudder torque as given in 3.1 and 3.2 causes bending moments and shear forces in the rudder body, bending moments and torques in the rudder stock, supporting forces in pintle bearings and rudder stock bearings and bending moments, shear forces and torques in rudder horns and heel pieces. The rudder body is to be stiffened by horizontal and vertical webs enabling it to act as a bending girder.

3.3.2 The bending moment (BM) and shear force (SF) distributions along the entire height of the rudder blade and rudder stock as well as the bearing reactions may be obtained by direct calculation. The rudder is to be assumed as simply supported at the centres of the upper bearing and the neck bearing. In case of rudders supported by the sole piece or rudder horn the flexibility of the sole piece or rudder horn, and rudder and rudder stock is to be taken into consideration. Guidelines for calculation of bending moment and shear force distribution for various types of rudders are given in Section 8.

Section 4

Rudder Blades

4.1 Construction details

4.1.1 Care is to be taken to avoid notch effects and to maintain continuity of strength around cut-outs and openings in the side plating. The plating thickness is to be increased suitably and corners are to be well rounded and ground smooth.

4.1.2 Side plating and vertical webs transmitting the torque are to be welded to the coupling flange by full penetration welds. Welds between plates and heavy pieces (solid parts in forged or cast steel or very thick plating) are also to be made as full penetration welds. In way of highly stressed areas e.g. cut-out of semi-spade rudder and upper part of spade rudder, cast or welding on ribs is to be arranged. Two sided full penetration welding is normally to be arranged. Where back welding is impossible welding is to be performed against ceramic backing bars or equivalent. Steel backing bars may be used and are to be continuously welded on one side to the heavy piece.

4.1.3 Webs are to be connected to the side plating in accordance with Ch.17. Where fillet welding is not practicable side plating is to be connected by means of slot welding to flat bars welded to the webs. Slot welding is to be limited as far as possible. Slot welding is not to be used in areas with large in-plane stresses transversely to the slots or in way of cut-out areas of semi-spade rudders. Normally slots of length 75 [mm], breadth at least twice the side plating thickness and spaced 200 [mm] centre to centre will be accepted. The ends of the slots are to be well rounded. The slots are to be fillet welded around the edges and filled with a suitable compound, e.g. epoxy putty. Slots are not to be filled with weld.

4.1.4 Continuous slot welds may be used in lieu of slot welds. When continuous slot welding is used, the root gap is to be between 6-10 [mm] and the bevel angle is to be atleast 15º.

4.1.5 In way of the rudder horn recess of semi-spade rudders, the radii in the rudder plating are not to be less than 5 times the plate thickness, but in no case less than 100 [mm]. Welding in side plate is to be avoided in or at the end of the radii. Edges of side plate and weld adjacent to radii are to be ground smooth.

4.1.6 Requirements for welding and design details of rudder trunks are indicated in 7.3.

4.1.7 Requirements for welding and design details when the rudder stock is connected to the rudder by horizontal flange coupling are indicated in 6.1.6.

4.1.8 Requirements for welding and design details of rudder horns are indicated in 7.2.3.

4.1.9 Arrangement is to be provided to drain the rudders completely. Drain plugs are to be provided with efficient packing.

4.1.10 Internal surfaces of rudders are to be efficiently coated for corrosion resistance after completion of fabrication and testing. Where it is intended to fill the rudder with plastic foam, details of the foam material are to be submitted.

4.2 Double plated rudders

4.2.1 Thickness 't' of the rudder side, top and bottom plating is not to be less than:

$$t = 5.5.s.f_a.\sqrt{k.\left(T + \frac{F_r}{A}.10^{-4}\right)}.10^{-3} + 2.5 \text{ [mm]}$$

where,

$$f_a = \sqrt{1.1 - 0.5(s/1000/l)^2};\ \max.1.00$$

s = the smaller of the distances between the horizontal or the vertical web plates/ smallest unsupported width of plating [mm].

l = the larger of the distances between the horizontal or the vertical web plates/ greatest unsupported width of plating [m].

T = Summer load line draught [m]

k = Material factor for the rudder plating.

The thickness 't' is however not to be less than the minimum side shell thickness as per Pt.3, Ch.8.

For nose plates the thickness is to be increased to 1.25 t.

4.2.2 The thickness of the vertical and horizontal webs is not to be less than 70 per cent of the requirement given in 4.2.1 with a minimum of 8 [mm].

4.2.3 Overall strength of the rudder blade based on bending moments (BM) and shear forces (SF) obtained as per Sec.3 is to satisfy the following criteria:

a) bending stress $\sigma = \frac{\mathrm{BM}}{\mathrm{Z}_l} \leq 110/\mathrm{k}\ [\mathrm{N/mm^2}]$

b) shear stress $\tau = \frac{\mathrm{SF}}{\mathrm{A_w}} \leq 50/\mathrm{k}\ [\mathrm{N/mm^2}]$

c) equivalent stresses

$$\sigma_{\mathrm{a}} = \sqrt{\sigma^2 + 3\tau^2} \leq 120/\mathrm{k}\ [\mathrm{N/mm^2}]$$

where,

Z_l = Section modulus of the blade cross section against lateral bending obtained considering side plating and web plates within the effective width of the rudder profile. The effective width is to be generally taken as 40 per cent of the net width of the rudder profile; and

A_w = Total Sectional area of the vertical webs.

k = Material factor for the rudder plating

d) In way of cut-outs or openings in the side plating for access to cone coupling or pintle nut:

Bending stress, $\sigma \leq 75$ [N/mm^2]

Torsional stress, $\tau_t \leq 50$ [N/mm^2]

$$\sqrt{\sigma^2 + 3\tau^2} \leq 100/\mathrm{k}\ [\mathrm{N/mm^2}]$$

where,

τ_t is torsional stress based on torque arising from the partial rudder force acting on the area below the section in consideration.

Note : The stresses in d) apply equally to high tensile and ordinary steels.

e) In way of the coupling the stresses are to be limited as in d); however for calculation of the stresses only the items within the width of the coupling are to be considered.

4.3 Single plated rudders

4.3.1 Mainpiece diameter

The mainpiece diameter is calculated according to 5.1.1 and 5.1.4 respectively. The diameter of the main piece at top end is not to be less than that of the lower rudder stock, and it may be gradually reduced towards lower end provided stresses are limited as per 4.2.3. For spade rudders the lower third may taper down to 0.75 times stock diameter.

4.3.2 Blade thickness

The blade thickness is not to be less than:

$$t_b = 1.5\, s\, V\sqrt{k} + 2.5 \qquad [\mathrm{mm}]$$

where:

s = spacing of stiffening arms, [m], not to exceed 1 m;

V = speed in knots, see 3.1.1.

k = material factor for the rudder plating.

4.3.3 Arms

The thickness of the arms is not to be less than the blade thickness

$t_a = t_b$ [mm]

The section modulus is not to be less than:

$Z_a = 0.5\, s\, C_1^2\, V^2\, k$ [cm^3];

C_1 = horizontal distance from the aft edge of the rudder to the centreline of the rudder stock, [m]

k = material factor

4.3.4 Rudder blade is to be stiffened by horizontal arms spaced not more than 1000 [mm] apart. The arms are to be efficiently attached to the main piece.

4.4 Connection of rudder blade structure with solid parts

4.4.1 Solid parts in forged or cast steel, which house the rudder stock or the pintle, are normally to be provided with protrusions.

These protrusions are not required when the web plate thickness is less than:

- 10 [mm] for web plates welded to the solid part on which the lower pintle of a semi-spade rudder is housed and for vertical web plates welded to the solid part of the rudder stock coupling of spade rudders.

- 20 [mm] for other web plates.

4.4.2 The solid parts are in general to be connected to the rudder structure by means of two horizontal web plates and two vertical web plates.

4.4.3 Minimum section modulus of the connection with the rudder stock housing.

The section modulus of the cross-section of the structure of the rudder blade, in [cm^3], formed by vertical web plates and rudder plating, which is connected with the solid part where the rudder stock is housed is to be not less than:

$$Z_s = c_s\, d_c^3 \left(\frac{H_E - H_X}{H_E}\right)\frac{k}{k_s}\; 10^{-4} \quad [\text{cm}^3]$$

where:

c_s = coefficient, to be taken equal to:

= 1.0 if there is no opening in the rudder plating or if such openings are closed by a full penetration welded plate

= 1.5 if there is an opening in the considered cross-section of the rudder

d_c = rudder stock diameter, [mm]

H_E = vertical distance between the lower edge of the rudder blade and the upper edge of the solid part, [m]

H_X = vertical distance between the considered cross-section and the upper edge of the solid part, [m]

k = material factor for the rudder blade plating.

k_s = material factor for the rudder stock.

The actual section modulus of the cross-section of the structure of the rudder blade is to be calculated with respect to the symmetrical axis of the rudder.

The breadth of the rudder plating, [m], to be considered for the calculation of section modulus is to be not greater than:

$$b = s_V + 2\,H_x / 3 \quad [\text{m}]$$

where:

s_V = spacing between the two vertical webs, [m] (see Fig.4.4.3)

Where openings for access to the rudder stock nut are not closed by a full penetration welded plate, they are to be deducted.

4.4.4 The thickness of the horizontal web plates connected to the solid parts, in [mm], as well as that of the rudder blade plating between these webs, is to be not less than the greater of the following values:

t_H = 1.2 t [mm]

t_H = $0.045\, d_s^2 / s_H$ [mm]

where:

t = defined in 4.2.1

d_S = diameter,[mm], to be taken equal to:

= d_c, as per 5.1.4, for the solid part housing the rudder stock

= d_p, as per 5.2.1, for the solid part housing the pintle

s_H = spacing between the two horizontal web plates, [mm]

The increased thickness of the horizontal webs is to extend fore and aft of the solid part at least to the next vertical web.

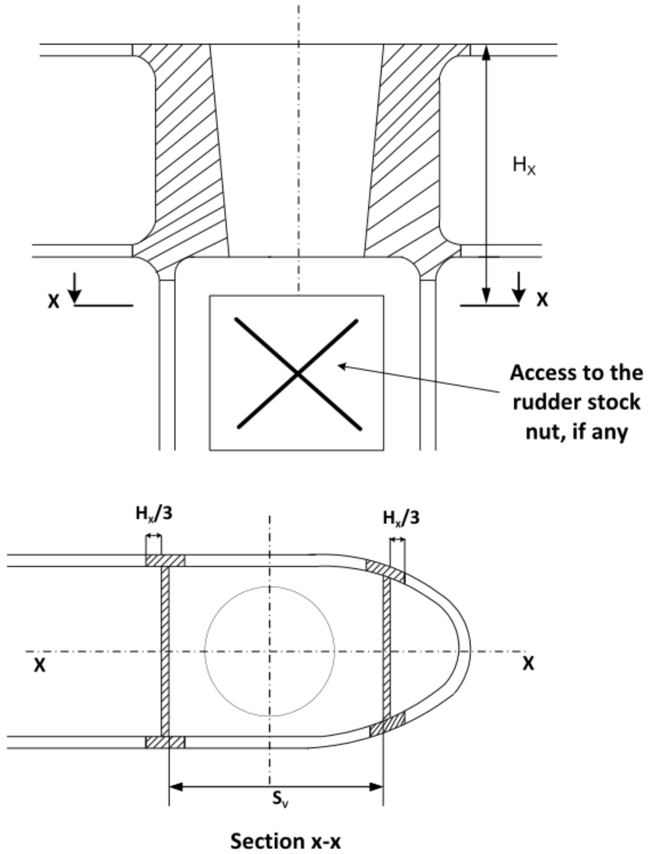


Fig.4.4.3 : Cross-section of the connection between rudder blade structure and rudder stock housing

4.4.5 The thickness of the vertical web plates welded to the solid part where the rudder stock is housed as well as the thickness of the rudder side plating under this solid part is to be not less than the values obtained, in [mm], from Table 4.4.5. The increased thickness is to extend below the solid piece at least to the next horizontal web.

Table 4.4.5 : Thickness of side plating and vertical web plates

Type of rudder	Thickness of vertical web plates, [mm]		Thickness of rudder plating, [mm]	
	Rudder blade without opening	Rudder blade with opening	Rudder blade without opening	Area with opening
Rudder supported by sole piece	1.2 t	1.6 t	1.2 t	1.4 t
Semi-spade and spade rudders	1.4 t	2.0 t	1.3 t	1.6 t
t = thickness of the rudder plating, [mm] as defined in 4.2				

Section 5

Rudder Stock and Pintles

5.1 Rudder stock

5.1.1 The rudder stock diameter required for the transmission of the rudder torque is to be dimensioned such that the torsional stress is not exceeding the following value:

$$\tau_T = 68 / k \text{ [N/mm}^2\text{]}$$

The rudder stock diameter for the transmission of the rudder torque is therefore not to be less than:

$$d_t = 4.2\sqrt[3]{Q_r k} \text{ [mm]}$$

Q_r = Total rudder torque [Nm] as calculated in 3.2.

k = Material factor of the rudder stock as given in 1.2.3

5.1.2 If the rudder stock is subjected to combined torque and bending, the Equivalent stress σ_e in the rudder stock is not to exceed 118/k [N/mm^2] i.e.

k = Material factor of the rudder stock as given in 1.2.3

$$\sigma_e = \sqrt{\sigma^2 + 3\tau_t^{\ 2}} \le 118/\mathrm{k} \text{ [N/mm}^2\text{]}$$

where,

σ is the bending stress in [N/mm^2],

$\sigma = 10.2 \text{ x } 10^3 \text{ M } / \mathrm{d}_c^3$

τ_t is the torsional shear stress in [N/mm^2].

$\tau_t = 5.1 \text{ x } 10^3 \text{ Q}_r / \mathrm{d}_c^3$

This requirement is regardless of the liners; and both ahead and astern conditions are to be considered.

5.1.3 The diameter of the rudder stock at and above rudder carrier is given by

$$\mathrm{d}_t = 4.2\sqrt[3]{(\mathrm{Q}_r.\mathrm{k})} \text{ [mm]}$$

5.1.4 The diameter of rudder stock at any other cross section is given by

$$\mathrm{d}_s = d_t . \sqrt[6]{\left[1 + \frac{4}{3}.\frac{\mathrm{BM}^2}{\mathrm{Q}_r^2}\right]} \text{[mm]}$$

where BM is the bending moment at the cross section under consideration obtained as per 3.3.

5.1.5 The diameter of the rudder stock at neck bearing is to be maintained to a point as far as practicable above the top of the neck bearing and may subsequently be tapered to that required at the rudder carrier. The length of the taper is to be at least three times the reduction in diameter. Particular care is to be taken to avoid the formation of a notch at the upper end of the taper.

5.1.6 Sudden changes of section or sharp corners in way of the rudder coupling, jumping collars and shoulders for rudder carriers are to be avoided. Jumping collars are not to be welded to the rudder stock. Keyways in the rudder stock are to have rounded ends and the corners at the base of the keyway are to be adequately radiused.

5.1.7 Significant reductions in rudder stock diameter due to the application of steels with yield stresses exceeding 235 [N/mm^2] are to be granted only after evaluation of rudder stock deformations. Large deformations of the rudder stock are to be avoided in order to avoid excessive pressures in way of bearings.

5.2 Pintles

5.2.1 Scantlings

The diameter d_p of the pintles, is not to be less than

$$d_p = 0.35\sqrt{(B\,k_p)}$$

where,

B = relevant bearing force, [N]

k_p = material factor for pintle as given in 1.2.3

5.2.2 Couplings

Pintles are to have a conical attachment to the gudgeons with a taper on diameter not greater than:

1:8 - 1:12 for keyed and other manually assembled pintles applying locking by slugging nut,

1:12 - 1:20 on diameter for pintles mounted with oil injection and hydraulic nut.

5.2.3 Push-up pressure for pintle bearings

The required push-up pressure for pintle bearings, in [N/mm²], is to be determined by the following formula:

$$p_{req} = 0.4\,\frac{B_1 d_0}{d_m^2\, l}$$

where:

B_1 = Supporting force in the pintle bearing, [N]

d_0, d_m, l = Pintle dimensions, see Fig. 6.3.1

5.2.4 The minimum dimensions of threads and nuts are to be determined according to Cl. 6.3.2. The push-up length is to be calculated similarly as in Cl. 6.4.3, using required push-up pressure and properties for the pintle bearing. An effective sealing against sea water is to be provided at both ends of the cone.

5.2.5 Pintle housing

The length of pintle housing in the gudgeon is not to be less than the pintle diameter d_p. The thickness of the pintle housing is not to be less than 0.25 d_p.

5.2.6 Where liners are fitted to pintles, they are to be shrunk on or otherwise efficiently secured. If liners are to be shrunk on, the shrinkage allowance is to be indicated on the plans. Where liners are formed by stainless steel weld deposit, the pintles are to be of weldable quality steel, and details of the procedure are to be submitted. Bushing is to be effectively secured against movement.

5.3 Bearings of rudder stock, rudder shaft and pintle

5.3.1 Liners and Bushes

5.3.1.1 Rudder stock bearing

Liners and bushes are to be fitted in way of bearings. The minimum thickness of liners and bushes is to be equal to:

- t_{min} = 8 [mm] for metallic materials and synthetic material
- t_{min} = 22 [mm] for lignum material

5.3.1.2 Pintle bearing

The thickness of any liner or bush, [mm], is neither to be less than:

$$t = 0.01\sqrt{B}$$

where:

B = relevant bearing force, [N]

nor less than the minimum thickness defined in 5.3.1.1

5.3.2 Minimum Bearing Surface

5.3.2.1 An adequate lubrication is to be provided. The bearing surface A_b (defined as the projected area: length x outer diameter of liner) is not to be less than:

$$A_b = {}^{P}\!/_{q_a}$$

where:

P = reaction force [N] in bearing as determined in 3.3;

q_a = allowable surface pressure according to the Table 5.3.2.

5.3.3 Bearing clearances are normally to be as given in Table 5.3.3.

Attention is to be paid to the manufacturer's recommendations particularly where bush material requires pre-soaking.

5.3.4 The maximum surface pressure p, for the various combinations is not to exceed the values given in Table 5.3.4. Higher values than given in table may be taken on verification by tests.For the purpose of this calculation, the bearing length is not to be taken greater than 1.2 times the rudder stock or pintle diameter measured outside of liners, if fitted. The bearing length L_p of the pintle is to be such that

$$D_p \leq L_p \leq 1.2\, D_p$$

where,

D_p = Actual pintle diameter measured on the outside of the liners.

Table 5.3.3 : Bearing clearances

- For metal bearing material	Not less than 0.001 d_p + 1.0 [mm]
- For synthetic bearing material	To be specially determined considering the swelling and thermal expansion properties of the material, but not less than 1.5 [mm]#.

A smaller clearance may be accepted if supported by the manufacturer’s recommendation and documented evidence of satisfactory service history with reduced clearance.

Table 5.3.4 : Maximum surface pressure q_a

Bearing material	**q_a [N/mm^2]**
Lignum vitae	2.5
White metal, oil lubricated	4.5
Synthetic material with hardness between 60 and 70 shore D(1)	5.5(2)
Steel,(3) bronze and hot pressed bronze- graphite materials	7.0

Note:

(1) Indentation hardness test at 23°C and with 50% moisture, according to a recognised standard. Synthetic bearing materials to be of approved type.

(2)Surface pressures exceeding 5.5 [N/mm^2] may be accepted in accordance with the bearing manufacturer’s specification and tests, but in no case more than 10 [N/mm^2]

(3) Stainless and wear resistant steel in an approved combination with stock liner.

Section 6

Rudder Couplings

6.1 Horizontal flange couplings

6.1.1 The diameter of the coupling bolts is not to be less than:

$$d_b = 0.62\left[\frac{d_s^3 . k_b}{n.e_m.k_s}\right]^{1/2} \text{ [mm]}$$

where,

d_s = Stock diameter [mm] in way of the coupling flange; equal to the greater of the diameters d_t or d_c according to 5.1.3 and 5.1.4

k_s = material factor for the rudder stock material;

k_b = material factor for the bolt material;

n = total number of bolts;

e_m = mean distance of the bolt axes from the centre of the bolt system [mm].

6.1.2 Coupling bolts are to be fitted bolts and a minimum of six (6) bolts are to be provided. Their nuts are to be effectively locked.

6.1.3 Mean distance e_m from the centre of the bolts to the centre of the bolt system is not to be less than 0.9 d_s [mm]. In addition, where the coupling is subjected to bending stress the mean athwartship distance from the centre of bolts to the longitudinal centreline of the coupling is not to be less than 0.6 d_s [mm].

6.1.4 The thickness of coupling flanges is not to be less than that obtained by the following formula:

$$t_f = d_b \sqrt{\left(\frac{k_f}{k_b}\right)} \text{ [mm]}$$

t_f is to be also not less than 0.9 d_b;

d_b = bolt diameter [mm] calculated for a number of bolts not exceeding 8.

k_f = material factor for the flange;

k_b = material factor for the bolt material.

6.1.5 The width of material outside the bolt holes is not to be less than 0.67 d_b [mm].

6.1.6 The welded joint between the rudder stock and the flange is to be made in accordance with Fig.6.1.6 or equivalent.

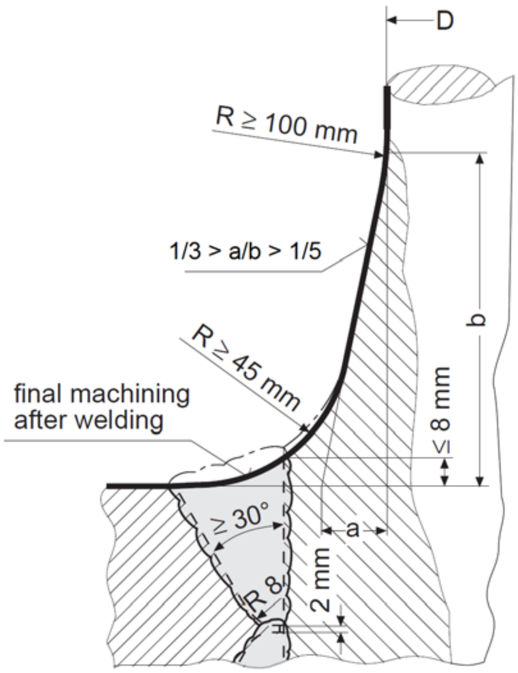


Fig. 6.1.6 : Welded joint between rudder stock and coupling flange

6.2 Vertical flange couplings

6.2.1 The diameter of the coupling bolts is not to be less than:

$$d_b = 0.81\left[\frac{d_s^2 \, . k_b}{n \, . k_s}\right]^{1/2} \quad [mm]$$

where,

d_s = Stock diameter [mm] in way of the coupling flange

n = total number of bolts , but not less than 8.

k_b = material factor for bolts.

k_s = material factor for rudder stock .

6.2.2 The first moment of area of the bolts about the centre of the coupling to be not less than:

$$m = 0.00043 \, d_s^3 \; [cm^3]$$

6.2.3 The thickness of the coupling flanges is to be at least equal to the bolt diameter; and the width of the flange material between the perimeter of the bolt holes and the perimeter of the flange is to be greater than or equal to 0.67 d_b.

6.2.4 Coupling bolts are to be fitted bolts and their nuts are to be locked effectively.

6.3 Cone couplings with key/ Cone couplings without hydraulic arrangement for mounting and dismounting

6.3.1 Cone couplings without hydraulic arrangements for mounting and dismantling the coupling should have a taper 'c' on diameter generally ranging between 1:8 to 1:12.

$$c = \frac{d_o - d_u}{l} \text{ according to Fig.6.3.1.}$$

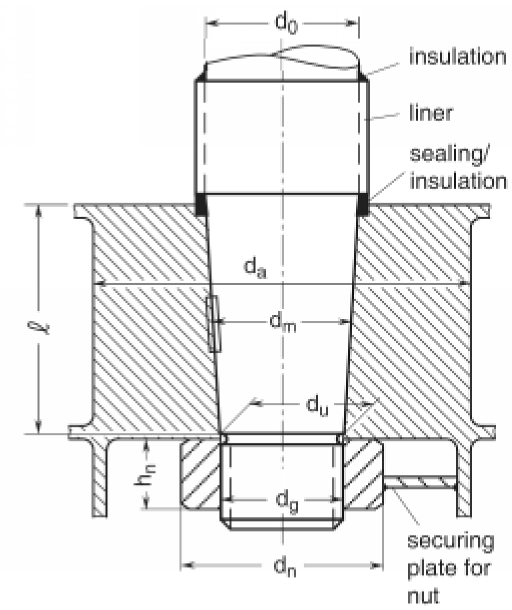


Fig.6.3.1 : Cone coupling with key

The coupling length *l* is in general not to be less than 1.5 times the rudder stock diameter d_o at the top of rudder.

The cone shape is to be very exact and the slugging nut is to be efficiently secured.

6.3.2 The dimensions of the slugging nut [mm], are not to be less than (See Fig 6.3.1) :

External thread of nut, $d_g \geq 0.65 \, d_o$;

Outer diameter of nut, $d_n \geq 1.2 \, d_u$ or $1.5 \, d_g$, whichever is the greater;

Height of nut, $h_n \geq 0.6\ d_g$

6.3.3 A key is to be fitted in the tapered connection, as close to the nut as possible and ample fillets are to be provided at corners of the keyway.

The shear area of the key is not to be less than :

$$a_s = \frac{17.55\ Q_F}{d_k\ \sigma_{F1}}$$

where,

Q_F = design yield moment of rudder stock, in [Nm]

$$Q_F = 0.02664\ \frac{d_t^3}{k}$$

Where the actual diameter d_{ta} is greater than the calculated diameter d_t, the diameter d_{ta} is to be used. However, d_{ta} applied to the above formula need not be taken greater than 1.145 d_t.

d_t = stock diameter, [mm], according to 5.1.3.

k = material factor for stock as given in 1.2.3

d_k = mean diameter of the conical part of the rudder stock, [mm], at the key

σ_{F1} = minimum yield stress of the key material, [N/mm^2]

The effective surface area, [cm^2], of the key (without rounded edges) between key and rudder stock or cone coupling is not to be less than:

$$a_k = \frac{5\ Q_F}{d_k \sigma_{F2}}$$

where:

σ_{F2} = minimum yield stress of the key, stock or coupling material, [N/mm^2], whichever is less.

6.3.4 Push up

It is to be proved that 50% of the design yield moment is solely transmitted by friction in the cone couplings. This can be done by calculating the required push-up pressure and push-up length according to 6.4.2 and 6.4.3 for a torsional moment $Q'_F = 0.5\ Q_F$.

6.3.5 Notwithstanding the requirements in 6.3.3 and 6.3.4, where a key is fitted to the coupling between stock and rudder and it is considered that the entire rudder torque is transmitted by the key at the couplings, the scantlings of the key as well as the push-up force and push-up length are to be specially considered.

6.4 Cone couplings with hydraulic arrangement for mounting and dismounting (with oil injection and hydraulic nut)

6.4.1 Where the stock diameter exceeds 200 [mm], the press fit is recommended to be achieved by a hydraulic pressure connection. In such cases, the cone diameter is to be, c, generally ranging between 1:12 to 1:20.

In case of hydraulic pressure connections the nut is to be effectively secured against the rudder stock or the pintle.

For the safe transmission of the torsional moment by the coupling between rudder stock and rudder body the push-up pressure and the push-up length are to be determined according to 6.4.2 and 6.4.3 respectively.

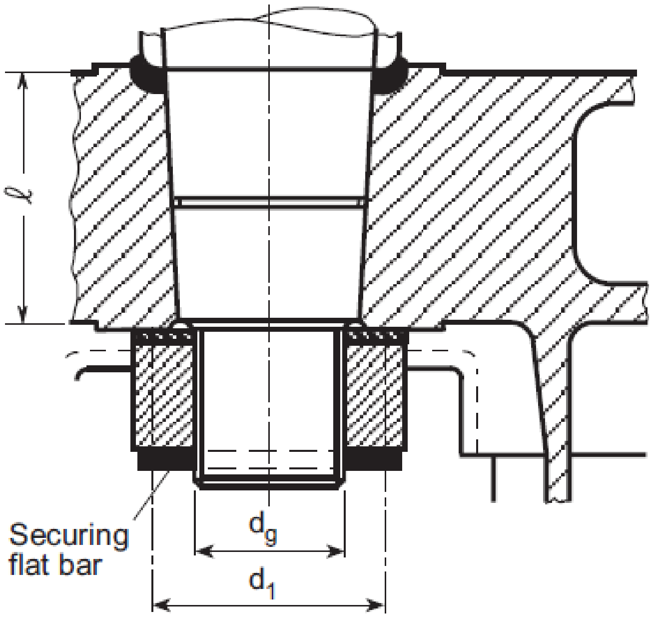


Fig.6.4.1 : Cone coupling without key

6.4.2 Push-up pressure

The push-up pressure is not to be less than the greater of the two following values:

$$p_{req1} = \frac{2Q_F}{d_m^2 \ell \pi \mu_0} 10^3 \qquad \text{[N/mm²]}$$

$$p_{req2} = \frac{6M_b}{\ell^2 d_m} 10^3 \qquad \text{[N/mm²]}$$

where:

Q_F = design yield moment of rudder stock, as defined in 6.3.3, [Nm]

d_m = mean cone diameter [mm], see Figure 6.3.1

ℓ = cone length [mm]

μ_0 = frictional coefficient, equal to 0.15

M_b = bending moment in the cone coupling (e.g. in case of spade rudders), [Nm]

It has to be proved by the designer that the push-up pressure does not exceed the permissible surface pressure in the cone. The permissible surface pressure, [N/mm²], is to be determined by the following formula:

$$p_{perm} = \frac{0.8R_{eH}\left(1-\alpha^2\right)}{\sqrt{3+\alpha^4}} \qquad \text{[N/mm²]}$$

where:

R_{eH} = minimum yield stress of the material of the gudgeon [N/mm^2]

α = d_m /d_a

d_m = diameter, [mm], see Fig. 6.3.1

d_a = outer diameter of the gudgeon to be not less than 1.5 d_m, [mm], see Fig.6.3.1

6.4.3 Push-up length

The push-up length $\Delta\ell$, [mm], $\Delta\ell$ is to comply with the following formula:

$$\Delta\ell_1 \le \Delta\ell \le \Delta\ell_2$$

where:

$$\Delta\ell_1 = \frac{p_{req} d_m}{E\left(\frac{1-\alpha^2}{2}\right)c} + \frac{0.8R_{tm}}{c} \qquad \text{[mm]}$$

$$\Delta\ell_2 = \frac{1.6R_{eH} d_m}{Ec\sqrt{3+\alpha^4}} + \frac{0.8R_{tm}}{c} \qquad \text{[mm]}$$

R_{tm} = mean roughness, [mm] taken equal to 0.01

c = taper on diameter according to 6.4.1

Notwithstanding the above, the push up length is not to be less than 2 [mm].

Note: In case of hydraulic pressure connections the required push-up force P_e, [N], for the cone may be determined by the following formula:

$$P_e = p_{req} d_m \pi \ell \left(\frac{c}{2} + 0.02 \right)$$

The value 0.02 is a reference for the friction coefficient using oil pressure. It varies and depends on the mechanical treatment and roughness of the details to be fixed. Where due to the fitting procedure a partial push-up effect caused by the rudder weight is given, this may be taken into account when fixing the required push-up length, subject to approval by IRS.

Section 7

Sole Pieces and Rudder Horns

7.1 Sole piece

The section modulus around the vertical (z)-axis is not to be less than:

Z_z = M_b k / 80 [cm^3]

The section modulus around the transverse (y)-axis is not to be less than:

Z_y = 0.5 Z_z

The sectional area is not to be less than:

A_s = B_1 k / 48 [mm^2]

k = material factor as given in 1.2.3

7.1.1 Equivalent stress

At no section within the length ℓ_{50} is the equivalent stress to exceed 115 / k [N/mm^2]. The equivalent stress is to be determined by the following formula (See Fig.8.4.2):

$$\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} \quad [\text{N/mm}^2];$$

where:

σ_b = M_b / Z_z(x) [N/mm^2];

τ = B_1 / A_s [N/mm^2];

M_b = bending moment at the section considered [Nm];

M_b = B_1 x [Nm];

M_{bmax} = B_1 ℓ_{50} [Nm];

B_1 = supporting force in the pintle bearing [N] (normally B_1 = C_R / 2).

k = material factor as given in 1.2.3

7.2 Rudder horn

When the connection between the rudder horn and the hull structure is designed as a curved transition into the hull plating, special consideration is to be given to the effectiveness of the rudder horn plate in bending and to the stresses in the transverse web plates.

The bending moments and shear forces are to be determined by a direct calculation or in line with the guidelines given in Section 8 for semi spade rudder with one elastic support and semi spade rudder with 2-conjugate elastic support respectively.

The section modulus around the horizontal x-axis is not to be less than:

Z_x = M_b k / 67 [cm^3].

M_b = bending moment at the section considered, [Nm];

The shear stress is not to be larger than:

τ = 48 / k [N/mm^2].

k = material factor as given in 1.2.3

7.2.1 Equivalent stress

At no section within the height of the rudder horn is the equivalent stress to exceed 120 / k N/mm^2. The equivalent stress is to be calculated by the following formula:

$$\sigma_e = \sqrt{\sigma_b^2 + 3\left(\tau^2 + \tau_T^2\right)} \text{ [N/mm}^2\text{];}$$

σ_b = M_b / Z_x [N/mm^2];

τ = B_1 / A_h [N/mm^2];

B_1 = supporting force in the pintle bearing [N];

A_h = effective shear area of rudder horn in y-direction [mm^2];

τ_T = $M_T 10^3 / 2 A_T t_h$ [N/mm^2];

M_T = torsional moment [Nm];

A_T = area in the horizontal section enclosed by the rudder horn [mm^2];

t_h = plate thickness of rudder horn [mm];

k = material factor as given in 1.2.3

7.2.2 Rudder horn plating

The thickness of the rudder horn side plating is not to be less than:

$$t = 2.4\sqrt{Lk} \quad \text{[mm]}$$

where:

L = Rule length as defined in Chapter 1, Cl. 2.1.3;

k = material factor as given in 1.2.3.

7.2.3 Welding and connection to hull structure

.1 The rudder horn plating is to be effectively connected to the aft ship structure, e.g. by connecting the plating to side shell and transverse/ longitudinal girders, in order to achieve a proper transmission of forces, see Figure 7.2.3.

.2 Brackets or stringer are to be fitted internally in horn, in line with outside shell plate, as shown in Figure 7.2.3.

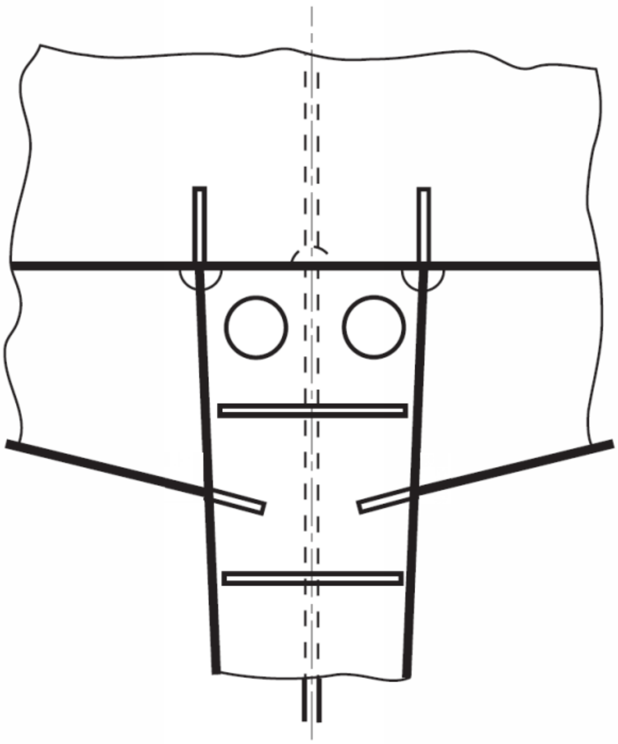


Fig.7.2.3 : Connection of Rudder Horn to aft Ship Structure

.3 Transverse webs of the rudder horn are to be led into the hull up to the next deck in a sufficient number.

.4 Strengthened plate floors are to be fitted in line with the transverse webs in order to achieve a sufficient connection with the hull.

.5 The centre line bulkhead (wash-bulkhead) in the after peak is to be connected to the rudder horn.

.6 Scallops are to be avoided in way of the connection between transverse webs and shell plating.

.7 The weld at the connection between the rudder horn plating and the side shell is to be full penetration. The welding radius is to be as large as practicable and may be obtained by grinding.

7.3 Rudder trunk

7.3.1 Materials, welding and connection to hull

This requirement applies to both trunk configurations (extending or not below stern frame).

The steel used for the rudder trunk is to be of weldable quality, with a carbon content not exceeding 0.23% on ladle analysis and a carbon equivalent C_{EQ} not exceeding 0.41.

Plating materials for rudder trunks are in general not to be of lower grades than corresponding to Class II as defined in Part 2 of the Rules.

The weld at the connection between the rudder trunk and the shell or the bottom of the skeg is to be full penetration.

The fillet shoulder radius r, [mm] (see Figure 7.2.4) is to be as large as practicable and to comply with the following formulae:

r = 60 [mm] when $\sigma \geq 40/k$ [N/mm^2]

r = $0.1d_c$, without being less than 30 [mm] when $\sigma < 40/k$ [N/mm^2]

where:

d_c = rudder stock diameter axis defined in 5.1.

σ = bending stress in the rudder trunk, [N/mm²].

k = material factor as given in 1.2.3

The radius may be obtained by grinding. If disk grinding is carried out, score marks are to be avoided in the direction of the weld. The radius is to be checked with a template for accuracy. Four profiles at least are to be checked. A report is to be submitted to the attending Surveyor.

Rudder trunks comprising of materials other than steel would be specially considered.

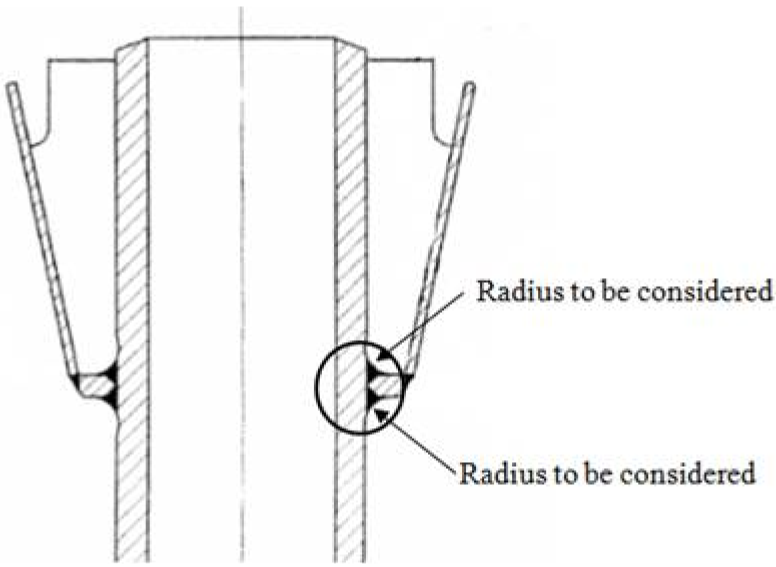


Fig.7.2.4 : Fillet Shoulder Radius

7.3.2 Scantlings

Where the rudder stock is arranged in a trunk in such a way that the trunk is stressed by forces due to rudder action, the scantlings of the trunk are to be such that:

- the equivalent stress due to bending and shear does not exceed 0.35 σ_F,
- the bending stress on welded rudder trunk is to be in compliance with the following formula: $\sigma \leq 80/k$ [N/mm²]

with:

σ = bending stress in the rudder trunk, as defined in 7.3.1.

k = material factor for the rudder trunk as given in 1.2.3, not to be taken less than 0.7

σ_F = yield stress [N/mm^2] of the material used.

For calculation of bending stress, the span to be considered is the distance between the mid-height of the lower rudder stock bearing and the point where the trunk is clamped into the shell or the bottom of the skeg.

Section 8

Guidelines for Evaluation of Bending Moment and Shear Force Distribution

8.1 The evaluation of bending moments, shear forces and support forces for the system rudder – rudder stock may be carried out for some basic rudder types as outlined in the succeeding paragraphs:

8.2 Spade rudder

8.2.1 Data for the analysis

ℓ_{10} - ℓ_{30} = Lengths of the individual girders of the system, [m]

$I_{10} – I_{30}$ = Moments of inertia of these girders, [cm^4]

Load of rudder body:

$P_R = C_R / (\ell_{10}\ 10^3)$ [kN/m]

8.2.2 The moments and forces may be determined by the following formulae:

$M_b = C_R (\ell_{20} + (\ell_{10} (2\ c_1 + c_2) / 3\ (c_1 + c_2)))$ [Nm]

$B_3 = M_b / \ell_{30}$ [N]

$B_2 = C_R + B_3$ [N]

8.3 Spade rudder with trunk

8.3.1 Data for the analysis

ℓ_{10} - ℓ_{30} = Lengths of the individual girders of the system, [m]

$I_{10} – I_{30}$ = Moments of inertia of these girders, [cm^4]

Load of rudder body:

$P_R = C_R / ((\ell_{10} + \ell_{20})10^3)$ [kN/m]

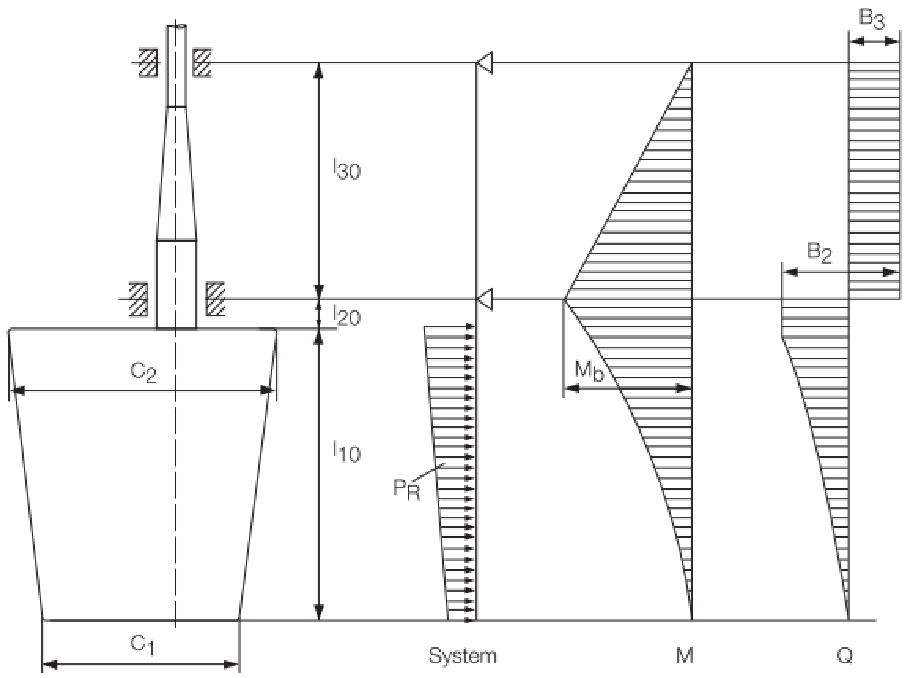


Fig.8.2.2 : Strength Calculations – Spade Rudder

8.3.2 For spade rudders with rudders trunks the moments, [Nm], and forces, [N], may be determined by the following formulae:

M_R is the greatest of the following values:

$$M_R = C_{R2}\,(\ell_{10} - CG_{2Z})$$

$$M_R = C_{R1}\,(CG_{1Z} - \ell_{10})$$

where:

C_{R1} : Rudder force over the rudder blade area A_1

C_{R2} : Rudder force over the rudder blade area A_2

CG_{1Z} : Vertical position of the centre of gravity of the rudder blade area A_1

CG_{2Z} : Vertical position of the centre of gravity of the rudder blade area A_2

$$M_B = C_{R2}\,(\ell_{10} - CG_{2Z})$$

$$B_3 = (M_B + M_{CR1}) / (\ell_{20} + \ell_{30})$$

$$B_2 = C_R + B_3$$

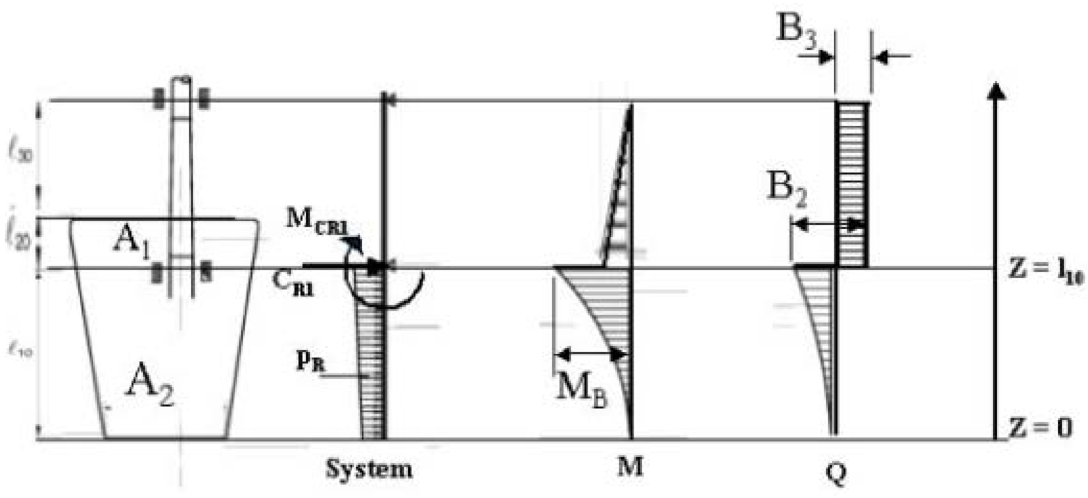


Fig.8.3.2 : Strength Calculations – Spade Rudder with Trunk

8.4 Rudder supported by sole piece

8.4.1 Data for the Analysis

ℓ_{10} - ℓ_{50} = Lengths of the individual girders of the system, [m]

I_{10} – I_{50} = Moments of inertia of these girders, [cm^4]

For rudders supported by a sole piece the length ℓ_{20} is the distance between lower edge of rudder body and centre of sole piece and I_{20} the moment of inertia of the pintle in the sole piece.

I_{50} = moment of inertia of sole piece around the z-axis, [cm^4];

ℓ_{50} = effective length of sole piece, [m];

Load of rudder body:

P_R = C_R / (ℓ_{10} 10^3) [kN/m]

Z = spring constant of support in the sole piece

Z = 6.18 x I_{50} / ℓ_{50}^3 [kN/m]

8.4.2 The moments and shear forces are indicated in Figure 8.4.2.

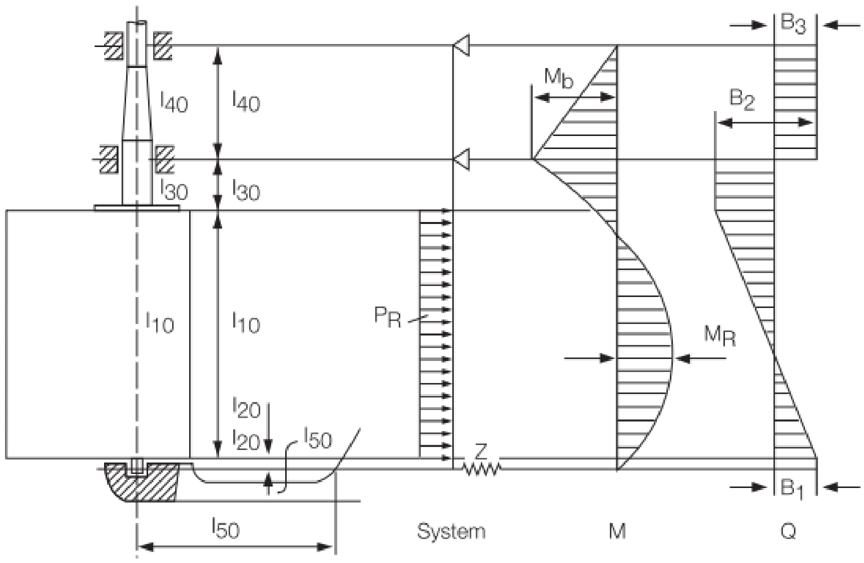


Fig.8.4.2 : Strength Calculations – Rudder supported by Sole Piece

8.5 Semi-spade rudder with one elastic support

8.5.1 Data for the analysis

ℓ_{10} - ℓ_{50} = Lengths of the individual girders of the system, [m];

I_{10} – I_{50} = Moments of inertia of these girders, [cm^4];

Z = spring constant of support in the rudder horn;

Z = 1 / (f_b + f_t) [kN/m] for the support in the rudder horn (Figure 8.5.2);

f_b = unit displacement of rudder horn in [m] due to a unit force of 1 kN acting in the centre of support;

f_b = 1.3 d^3 / (6.18 I_n) [m/kN] (guidance value);

I_n = moment of inertia of rudder horn around the x-axis, [cm^4] (see also Figure 8.5.2);

f_t = unit displacement due to torsion;

$f_t = d\, e^2 \sum {}^{u_i}/_{t_i} / [3.14 \times 10^8 F_T^2]$ [m/KN];

F_T = mean sectional area of rudder horn, [m^2];

u_i = breadth, [mm] of the individual plates forming the mean horn sectional area;

t_i = thickness within the individual breadth u_i, [mm];

d = Height of the rudder horn, [m], defined in Figure 8.5.2. This value is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the lower rudder horn pintle;

e = distance as defined in Figure 8.5.3

Load of rudder body:

P_{R10} = C_{R2} / (ℓ_{10} x 10^3) [kN/m];

P_{R20} = C_{R1} / (ℓ_{20} x 10^3) [kN/m];

for C_R, C_{R1}, C_{R2}, method indicated in 3.2.2 for estimation may be followed.

8.5.2 Moments and shear forces are indicated in Figure 8.5.2

8.5.3 Rudder horn

The loads on the rudder horn are as follows:

M_b = bending moment = B_1 z [Nm],

M_{bmax} = B_1 d [Nm]

q = shear force = B_1 [N]

M_T(z) = torsional moment = B_1 e (z) [Nm]

An estimate for B_1 is:

B_1 = C_R b / (ℓ_{20} + ℓ_{30}) [N]

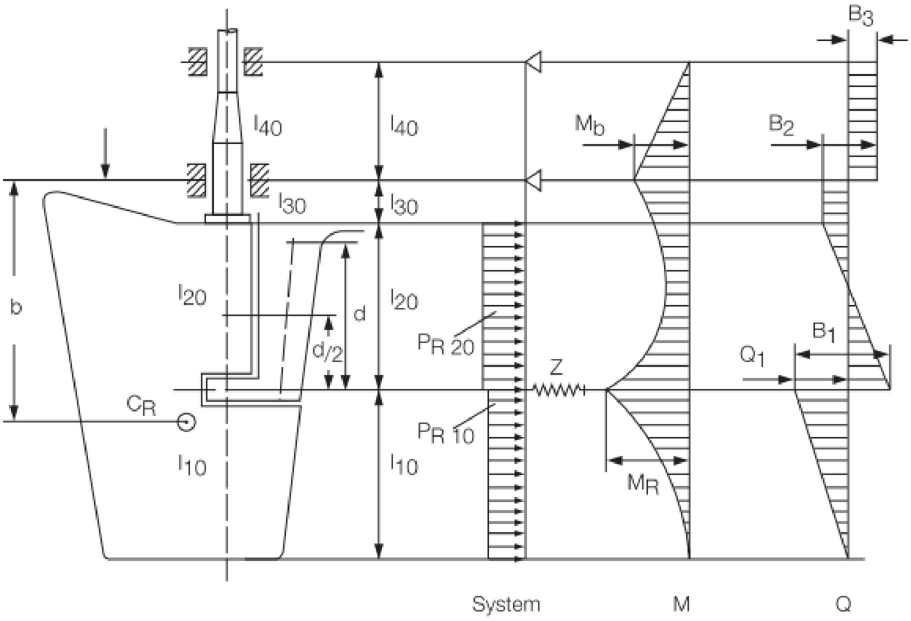


Fig.8.5.2 : Strength Calculations – Semi Spade Rudder with one Elastic Support

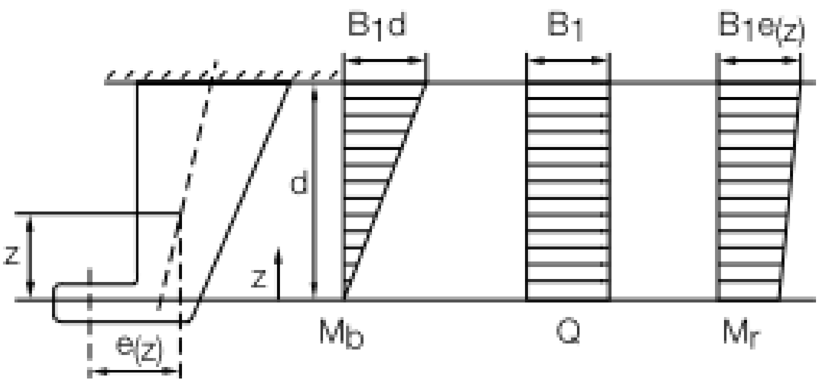


Fig 8.5.3

8.6 Semi-spade rudder with 2-conjugate elastic support

8.6.1 Data for the Analysis

K_{11}, K_{22}, K_{12} : Rudder horn compliance constants calculated for rudder horn with 2-conjugate elastic supports (Figure 8.6.2).The 2-conjugate elastic supports are defined in terms of horizontal displacements, y_i, by the following equations:

at the lower rudder horn bearing:

y_1 = $- K_{12} B_2 - K_{22} B_1$

at the upper rudder horn bearing:

y_2 = $- K_{11} B_2 - K_{12} B_1$

where:

y_1, y_2 : Horizontal displacements,[m], at the lower and upper rudder horn bearings, respectively.

B_1, B_2 : Horizontal support forces,[kN], at the lower and upper rudder horn bearings, respectively.

K_{11}, K_{22}, K_{12} : Obtained, [m/kN], from the following formulae:

$$K_{11} = 1.3\frac{\lambda^3}{3EJ_{1h}} + \frac{e^2\lambda}{GJ_{th}}$$

$$K_{22} = 1.3\left[\frac{\lambda^3}{3EJ_{1h}} + \frac{\lambda^2(d \quad \lambda)}{2EJ_{1h}}\right] + \frac{e^2\lambda}{GJ_{th}}$$

$$K_{12} = 1.3\left[\frac{\lambda^3}{3EJ_{1h}} + \frac{\lambda^2(d \quad \lambda)}{EJ_{1h}} + \frac{\lambda(d \quad \lambda)^2}{EJ_{1h}} + \frac{(d \quad \lambda)^3}{3EJ_{2h}}\right] + \frac{e^2 d}{GJ_{th}}$$

d : Height of the rudder horn, [m], defined in Figure 8.6.2. This value is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the lower rudder horn pintle.

λ : Length, [m], as defined in Figure 8.6.2. This length is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the upper rudder horn bearing. For λ = 0, the above formulae converge to those of spring constant Z for a rudder horn with 1-elastic support, and assuming a hollow cross section for this part.

e : Rudder-horn torsion lever, [m], as defined in Figure 8.6.2 (value taken at z = d/2).

J_{1h} : Moment of inertia of rudder horn about the x axis,[m^4], for the region above the upper rudder horn bearing. Note that J_{1h} is an average value over the length λ (see Figure 8.6.2).

J_{2h} : Moment of inertia of rudder horn about the x axis,[m^4], for the region between the upper and lower rudder horn bearings. Note that J_{2h} is an average value over the length d - λ (see Figure 8.6.2).

J_{th} : Torsional stiffness factor of the rudder horn, [m^4].

For any thin wall closed section:

$$J_{th} = \frac{4F_T^{\ 2}}{\sum_i \frac{u_i}{t_i}}$$

F_T : Mean of areas enclosed by outer and inner boundaries of the thin walled section of rudder horn, [m^2].

u_i : Length,[mm], of the individual plates forming the mean horn sectional area.

t_i : Thickness,[mm], of the individual plates mentioned above.

The J_{th} value is taken as an average value, valid over the rudder horn height.

Load of rudder body:

P_{R10} = $C_{R2} / (\ell_{10} \times 10^3)$ [kN/m];

$P_{R20} = C_{R1} / (\ell_{20} \times 10^3)$ [kN/m];

for C_R, C_{R1}, C_{R2}, see S10.2.2

8.6.2 The moments and shear forces are indicated in Fig.8.6.2.

8.6.3 Rudder horn bending moment

The bending moment acting on the generic section of the rudder horn is to be obtained, [Nm], from the following formulae:

- between the lower and upper supports provided by the rudder horn:

$M_H = F_{A1}\, z$

- above the rudder horn upper-support:

$M_H = F_{A1}\, z + F_{A2}\, (z - d_{lu})$

where:

F_{A1} : Support force at the rudder horn lower-support, [N], to be obtained according to Figure 8.6.2, and taken equal to B_1.

F_{A2} : Support force at the rudder horn upper-support, [N], to be obtained according to Figure 8.6.2, and taken equal to B_2.

z : Distance, [m], defined in Figure 8.6.3, to be taken less than the distance d, in [m], defined in the same figure.

d_{lu} : Distance, [m], between the rudder-horn lower and upper bearings (according to Figure 8.6.2, $d_{lu} = d - \lambda$).

8.6.4 Rudder horn shear force

The shear force Q_H, [N], acting on the generic section of the rudder horn is to be obtained, from the following formulae:

- between the lower and upper rudder horn bearings:

$Q_H = F_{A1}$

- above the rudder horn upper-bearing:
$Q_H = F_{A1} + F_{A2}$

where:

F_{A1}, F_{A2} : Support forces, in [N].

8.6.5 The torque, [Nm], acting on the generic section of the rudder horn is to be obtained from the following formulae:

- between the lower and upper rudder horn bearings:

$M_T = F_{A1}\, e_{(z)}$

- above the rudder horn upper-bearing:

$M_T = F_{A1}\, e_{(z)} + F_{A2}\, e_{(z)}$

where:

F_{A1}, F_{A2} : Support forces, in [N]

$e_{(z)}$: Torsion lever, [m], defined in Fig.8.6.3.

8.6.6 Rudder horn shear stress calculation

For a generic section of the rudder horn, located between its lower and upper bearings, the following stresses are to be calculated:

T_S: Shear stress, [N/mm^2], to be obtained from the following formula:

$$\tau_S = \frac{F_{A1}}{A_H}$$

T_T : Torsional stress, [N/mm^2], to be obtained for hollow rudder horn from the following formula:

$$\tau_T = \frac{M_T 10^3}{2F_T t_H}$$

For solid rudder horn, T_T is to be specially considered.

For a generic section of the rudder horn, located in the region above its upper bearing, the following stresses are to be calculated:

T_S: Shear stress, [N/mm^2], to be obtained from the following formula:

$$\tau_S = \frac{F_{A1} + F_{A2}}{A_H}$$

T_T : Torsional stress, [N/mm^2], to be obtained for hollow rudder horn from the following formula:

$$\tau_T = \frac{M_T 10^3}{2 F_T t_H}$$

For solid rudder horn, T_T is to be specially considered, where:

F_{A1}, F_{A2} : Support forces, [N];

A_H : Effective shear sectional area of the rudder horn, [mm^2], in y-direction;

M_T : Torque, [Nm];

F_T : Mean of areas enclosed by outer and inner boundaries of the thin walled section of rudder horn, [m^2];

t_H : Plate thickness of rudder horn,[mm]. For a given cross section of the rudder horn, the maximum value of T_T is obtained at the minimum value of t_H.

8.6.7 Rudder horn bending stress calculation

For the generic section of the rudder horn within the length *d*, the following stresses are to be calculated:

σ_B : Bending stress, [N/mm^2], to be obtained from the following formula:

$$\sigma_B = \frac{M_H}{W_X}$$

where:

M_H : Bending moment, [Nm] at the section considered.

W_X : Section modulus, [cm^3], around the X-axis (see Fig.8.6.3).

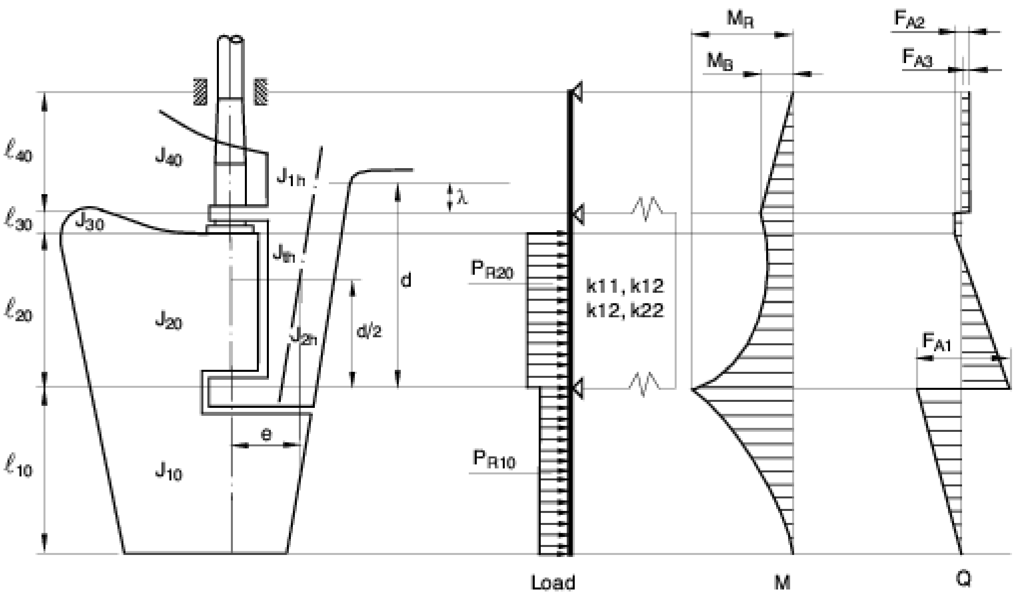


Fig.8.6.2 : Strength Calculations – Semi Spade Rudder with 2-conjugate Elastic Support

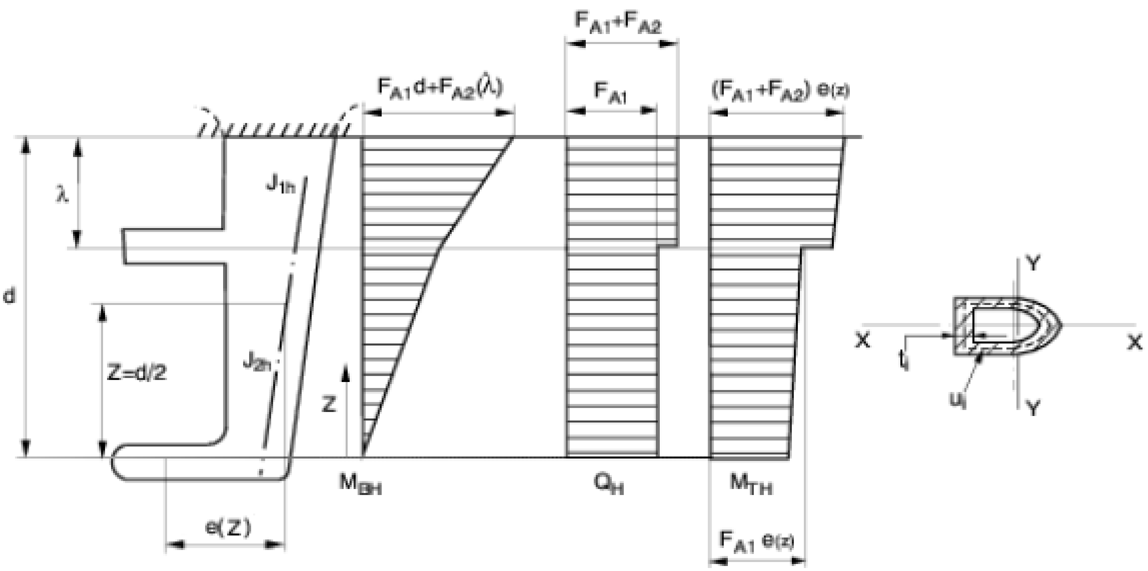


Fig.8.6.3

End of Chapter

Chapter 15

Anchoring and Mooring Equipment

Contents

Section

Section 1

General

1.1 Introduction

1.1.1 To entitle a vessel to the letter 'L' in her character of classification, anchoring and mooring equipment is to be provided in accordance with the requirements of this Chapter.

1.1.2 Except in case of supply vessels engaged in towing operations and tugs, towlines are not subject of classification and the details given in the equipment table are for guidance purpose only. Requirements for towlines for supply vessels engaged in towing operations and tugs are given in 3.2.4. However, for tugs intended to be classed for operations in harbours only, requirement of towline may be waived with written concurrence from the owner.

1.1.3 Attention is drawn to any relevant requirements of the National Authorities of the country in which the ship is to be registered.

1.2 Design of the anchoring equipment

1.2.1 The anchoring equipment required herewith is intended for temporary mooring of a vessel within a harbour or sheltered area when the vessel is awaiting berth, tide, etc.

1.2.2 The equipment is therefore not designed to hold a ship off fully exposed coasts in rough weather or to stop a ship which is moving or drifting. In this condition the loads on the anchoring equipment increase to such a degree that its components may be damaged or lost owing to the high energy forces generated, particularly in large ships.

1.2.3 The anchoring equipment presently required herewith is designed to hold a ship in good holding ground in conditions such as to avoid dragging of the anchor. In poor holding ground the holding power of the anchors will be significantly reduced.

1.2.4 The Equipment Numeral (EN) formula for anchoring equipment required here under is based on an assumed current speed of 2.5 m/sec. wind speed of 25 m/sec and a scope of chain cable between 6 and 10, the scope being the ratio between length of chain paid out and water depth.

1.2.5 It is assumed that under normal circumstances a ship will use only one bow anchor and chain cable at a time.

1.3 Documentation

1.3.1 The arrangements of anchoring and mooring and Equipment Number calculations are to be submitted for approval.

For vessels of 500 GT and above, towing arrangement plan is to be submitted for approval.

1.3.2 Following details of the proposed equipment are to be submitted for approval:-

1) Number, weight, type and design of anchors.

2) Length, diameter, grade and type of chain cables.

3) Type and breaking load of steel and fibre ropes.

1.4 Symbols

1.4.1 L,B,T,C_b and k as defined in Ch.1, Sec.2.

Section 2

Structural Arrangement for Anchoring Equipment

2.1 General

2.1.1 The anchors are normally to be housed in hawse pipes and anchor pockets of adequate size, scantlings and suitable form to prevent movement of anchor and chain due to wave action.

The arrangements are to provide an easy lead of chain cable from windlass to the anchors. Upon release of the brake, the anchors are to immediately start falling by their own weight. Substantial chafing lips are to be provided at shell and deck. These are to have sufficiently large, radiused faces to minimise the probability of cable links being subjected to large bending stresses. Alternatively, roller fairleads of suitable design may be fitted.

Alternative arrangements for housing of anchors will be specially considered.

2.1.2 The shell plating and framing in way of the hawse pipes are to be reinforced as necessary.

2.1.3 On ships provided with a bulbous bow, and where it is not possible to obtain ample clearance between shell plating and anchors during anchor handling, adequate local reinforcements on bulbous bow are to be provided.

2.1.4 The chain locker is to have adequate capacity and depth to provide an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. The chain pipes are to be of suitable size and provided with chafing lips. The port and starboard cables are to have separate spaces.

The chain lockers boundaries and chain pipes are to be watertight upto the weather deck. Bulkheads which form common boundary of chain lockers need not be watertight. Where a means of access to spurling pipes or cable lockers is located below the weather deck, the access cover and its securing arrangements are to be in accordance with recognized standards or equivalent for watertight manhole covers.

Provisions are to be made to minimize the ingress of water to the chain locker in bad weather. The chain pipes are to be provided with permanently attached closing appliances such as steel plates with cutouts for chain links or canvas hoods with lashing arrangements. For requirements regarding drainage of chain lockers, See Pt.4.

Provisions are to be made for securing the inboard ends of the chains to the structure. The strength of this attachment should be between 15 per cent to 30 per cent of the breaking strength of the chain cable. It is recommended that suitable arrangements be provided so that in an emergency the inboard end of the chain (bitter end) can be readily made to slip from an accessible position outside the chain locker.

2.1.5 The windlass and chain stoppers are to be efficiently bedded and secured to deck. The thickness of deck plating is to be increased in way of the windlass and chain stoppers and adequate stiffening underneath is to be provided.

Section 3

Equipment Specification

3.1 Equipment number

3.1.1 The equipment number, EN, on which the requirements of equipment are based is to be calculated as follows :-

$$EN = K.ENc$$

where,

$ENc = \Delta^{2/3} + 2BH + 0.1A$

Δ = moulded displacement, [t], to the summer load water line

H = effective height, [m], from the summer load waterline to the top of the uppermost deckhouse, to be measured as follows:

$H = a + \Sigma h_i$

a = distance [m] from summer load waterline amidships to the upper deck at side

h_i = height [m] on the centreline of each tier of houses having a breadth greater than B/4. For lowest tier, h_i is to be measured at centre line from upper deck, or from a notional deck line where there is a local discontinuity in the upper deck.

A = area [m^2] in profile view of the hull, superstructures and houses above the summer load waterline, which is within the Rule length of the vessel. Houses of breadth less than B/4 are to be disregarded.

In the calculation of H and A, sheer and trim are to be ignored.

Parts of windscreens or bulwarks which are more than 1.5[m] in height are to be regarded as parts of houses when determining H and A. The height of the hatch coamings and that of any deck cargo, such as containers, may be disregarded.

'K' is a factor depending upon the type of vessel and service notation as given below:

For fishing vessels,

K = 1.00

For other vessels,

K = 1.00 for vessels of Unrestricted Service.
K = 0.85 for vessels of Coastal Service
K = 0.775 for vessels of Restricted Water Service.
K = 0.50 for vessels of Sheltered Water Service.

3.1.2 For a barge rigidly connected to a push tug the equipment number is to be calculated for the combination regarded as one unit.

3.1.3 For tugs, while determining the equipment number EN, the term '2BH' in Sec.3.1.1 may be substituted by $2(aB + \Sigma h_i b_i)$ where b_i is the breadth, [m], of the widest superstructure or deckhouse of each tier having a breadth greater than B/4.

3.2 Equipment

3.2.1 For fishing vessels the equipment is to be in accordance with the requirements given in Table 3.2.1 using EN as calculated in 3.1.

3.2.2 For other vessels the equipment is to be in accordance with the requirements given in Table 3.2.2 using EN as calculated in 3.1.

3.2.3 The two bower anchors in Table 3.2.1 and Table 3.2.2 are to be connected to their cables and positioned onboard ready for use. The total length of chain is to be divided in approximately equal parts between the two bower anchors.

3.2.4 For tugs the particulars of towlines are to be based upon the maximum bollard pull and the intended duty of the vessel. However, in no case the breaking strength of the towline is to be less than twice the maximum bollard pull.

3.2.5 For offshore supply vessels the length and the diameter of chain cable is to be based on an equipment letter two steps higher than that corresponding to the EN of the vessel. Towline is to be as per 1.1.2

3.2.6 For unmanned barges and pontoons of length "L" less than 30 [m] no anchor need be provided.

Where length "L" is greater than or equal to 30 [m] only one anchor of the tabular weight need be provided. The attached chain cable is to be of the tabular diameter and 2 L [m] in length.

Two mooring lines of tabular breaking strength are to be provided where the length 'L' is less than 65 [m], otherwise three mooring lines are to be provided. The length of each mooring line is not be less than the greater of 2L [m] or 80 [m].

For unmanned barges and pontoons where the letter 'L' is not intended to be included in the character of classification only mooring lines of adequate length and strength need be provided.

3.2.7 For vessels of length less than 30 [m] the anchor chains may be replaced by wire ropes of equal strength. For vessels of length between 30 [m] and 40 [m] one chain cable may be replaced by wire rope of equal strength provided normal chain cable is maintained for the second line. For fishing vessels, wire ropes of trawl winches complying with the above may be used as anchor cables.

When wire ropes are substituted for anchor chains the following should be complied with :-

i) The length of ropes should be at least 1.5 times the corresponding tabular length of chain.

ii) A short length of chain shall be fitted between the anchor and the wire rope. The length of the cable need be the smaller of 12.5 [m] and the distance between the anchor in stowed position and the winch.

Table 3.2.1 : Equipment for fishing vessels

EN	Equipment letter	Stockless Bower Anchors		Stud-Link Chain Cables			Mooring Lines (Recommendation)		
					Diameter and chain grade		Steel or natural fibre ropes		
		Number	Mass per anchor [kg]	Total length [m]	CC1 [mm]	CC2 [mm]	Number	Length [m]	Breaking strength [kN]
30 & ≤ 40	A_of1	2	80	165	11		2	50	29
> 40 & ≤ 50	A_of2	2	100	192.5	11		2	60	29
> 50 & ≤ 60	Af1	2	120	192.5	12.5		2	60	34
> 60 & ≤ 70	Af2	2	140	192.5	12.5		2	80	34
> 70 & ≤ 80	Bf1	2	160	220	14	12.5	2	100	37
> 80 & ≤ 90	Bf2	2	180	220	14	12.5	2	100	37
> 90 & ≤ 100	Cf1	2	210	220	16	14	2	110	39
> 100 & ≤ 110	Cf2	2	240	220	16	14	2	110	44
> 110 & ≤ 120	Df1	2	270	247.5	17.5	16	2	110	44
> 120 & ≤ 130	Df2	2	300	247.5	17.5	16	2	110	49
> 130 & ≤ 140	Ef1	2	340	275	19	17.5	2	120	49
> 140 & ≤ 150	Ef2	2	390	275	19	17.5	2	120	49
> 150 & ≤ 175	Ff	2	480	275	22	19	2	120	54
>175 & ≤ 205	Gf	2	570	302.5	24	20.5	2	120	59
> 205 & ≤ 240	Hf	2	660	302.5	26	22	2	120	64
> 240 & ≤ 280	If	2	780	330	28	24	3	120	69
> 280 & ≤ 320	Jf	2	900	357.5	30	26	3	140	74
> 320 & ≤ 360	Kf	2	1020	357.5	32	28	3	140	78
> 360 & ≤ 400	Lf	2	1140	385	34	30	3	140	88
> 400 & ≤ 450	Mf	2	1290	385	36	32	3	140	98

Table 3.2.1 : (Contd.)

EN	Equipment letter	Stockless Bower Anchors		Stud-Link Chain Cables			Mooring Lines (Recommendation)		
					Diameter and chain grade		Steel or natural fibre ropes		
		Number	Mass per anchor [kg]	Total length [m]	CC1 [mm]	CC2 [mm]	Number	Length [m]	Breaking strength [kN]
> 450 & ≤ 500	Nf	2	1440	412.5	38	34	3	140	108
> 500 & ≤ 550	Of	2	1590	412.5	40	34	4	160	123
> 550 & ≤ 600	Pf	2	1740	440	42	36	4	160	132
> 600 & ≤ 660	QF	2	1920	440	44	38	4	160	147
> 660 & ≤ 720	Rf	2	2100	440	46	40	4	160	157

Table 3.2.2 : Equipment for vessels excluding fishing vessels

EN	Equipment letter	Stockless bower anchors		Stud-link chain cables for bower anchors				Towline (Recommendation)		Mooring lines [1]		
					Diameter and grade			Steel or natural fibre ropes				
		Number	Mass per anchor [kg]	Total length [m]	CC1 [mm]	CC2 [mm]	CC3 [mm]	Min. length [m]	Min. breaking strength [kN]	Number	Length of each [m]	Min. break-ing stren-gth [kN]
50 & ≤ 70	A	2	180	220	14	12.5		180	98	3	80	34
> 70 & ≤ 90	B	2	240	220	16	14		180	98	3	100	37
> 90 & ≤ 110	C	2	300	247.5	17.5	16		180	98	3	110	39
> 110 & ≤ 130	D	2	360	247.5	19	17.5		180	98	3	110	44
> 130 & ≤ 150	E	2	420	275	20.5	17.5		180	98	3	120	49
> 150 & ≤ 175	F	2	480	275	22	19		180	98	3	120	54
> 175 & ≤ 205	G	2	570	302.5	24	20.5		180	112	3	120	59
> 205 & ≤ 240	H	2	660	302.5	26	22	20.5	180	129	4	120	64
> 240 & ≤ 280	I	2	780	330	28	24	22	180	150	4	120	69
> 280 & ≤ 320	J	2	900	357.5	30	26	24	180	174	4	140	74
> 320 & ≤ 360	K	2	1020	357.5	32	28	24	180	207	4	140	78
> 360 & ≤ 400	L	2	1140	385	34	30	26	180	224	4	140	88
> 400 & ≤ 450	M	2	1290	385	36	32	28	180	250	4	140	98
> 450 & ≤ 500	N	2	1440	412.5	38	34	30	180	277	4	140	108
> 500 & ≤ 550	O	2	1590	412.5	40	34	30	190	306	4	160	123
> 550 & ≤ 600	P	2	1740	440	42	36	32	190	338	4	160	132
> 600 & ≤ 660	Q	2	1920	440	44	38	34	190	371	4	160	147
> 660 & ≤ 720	R	2	2100	440	46	40	36	190	406	4	160	157
> 720 & ≤ 780	S	2	2280	467.5	48	42	36	190	441	4	170	172
> 780 & ≤ 840	T	2	2460	467.5	50	44	38	190	480	4	170	186
> 840 & ≤ 910	U	2	2640	467.5	52	46	40	190	518	4	170	201
> 910 & ≤ 980	V	2	2850	495	54	48	42	190	559	4	170	216
> 980 & ≤ 1060	W	2	3060	495	56	50	44	200	603	4	180	230
> 1060 & ≤ 1140	X	2	3300	495	58	50	46	200	647	4	180	250

Table 3.2.2 (Contd.)

EN	Equipment letter	Stockless bower anchors		Stud-link chain cables for bower anchors				Towline (Recommendation)		Mooring lines [1)]		
				Total length [m]	Diameter and grade			Steel or natural fibre ropes				
		Number	Mass per anchor [kg]		CC1 [mm]	CC2 [mm]	CC3 [mm]	Min. length [m]	Min. breaking strength [kN]	Number	Length of each [m]	Min. breaking strength [kN]
> 1140 & ≤ 1220	Y	2	3540	522.5	60	52	46	200	691	4	180	270
> 1220 & ≤ 1300	Z	2	3780	522.5	62	54	48	200	738	4	180	284
> 1300 & ≤ 1390	A+	2	4050	522.5	64	56	50	200	786	4	180	309
> 1390 & ≤ 1480	B+	2	4320	550	66	58	50	200	836	4	180	324
> 1480 & ≤ 1570	C+	2	4590	550	68	60	52	220	888	5	190	324
> 1570 & ≤ 1670	D+	2	4890	550	70	62	54	220	941	5	190	333
> 1670 & ≤ 1790	E+	2	5250	577.5	73	64	56	220	1024	5	190	353
> 1790 & ≤ 1930	F+	2	5610	577.5	76	66	58	220	1109	5	190	378
> 1930 & ≤ 2080	G+	2	6000	577.5	78	68	60	220	1168	5	190	402
> 2080 & ≤ 2230	H+	2	6450	605	81	70	62	240	1259	5	200	422
> 2230 & ≤ 2380	I+	2	6900	605	84	73	64	240	1356	5	200	451
> 2380 & ≤ 2530	J+	2	7350	605	87	76	66	240	1453	5	200	480
> 2530 & ≤ 2700	K+	2	7800	632.5	90	78	68	260	1471	6	200	480
> 2700 & ≤ 2870	L+	2	8300	632.5	92	81	70	260	1471	6	200	490
> 2870 & ≤ 3040	M+	2	8700	632.5	95	84	73	260	1471	6	200	500
> 3040 & ≤ 3210	N+	2	9300	660	97	84	76	280	1471	6	200	520
> 3210 & ≤ 3400	O+	2	9900	660	100	87	78	280	1471	6	200	554
> 3400 & ≤ 3600	P+	2	10500	660	102	90	78	280	1471	6	200	588
> 3600 & ≤ 3800	Q+	2	11100	687.5	105	92	81	300	1471	6	200	618
> 3800 & ≤ 4000	R+	2	11700	687.5	107	95	84	300	1471	6	200	647
> 4000 & ≤ 4200	S+	2	12300	687.5	111	97	87	300	1471	7	200	647
> 4200 & ≤ 4400	T+	2	12900	715	114	100	87	300	1471	7	200	657
> 4400 & ≤ 4600	U+	2	13500	715	117	102	90	300	1471	7	200	667
> 4600 & ≤ 4800	V+	2	14100	715	120	105	92	300	1471	7	200	677
> 4800 & ≤ 5000	W+	2	14700	742.5	122	107	95	300	1471	7	200	686
> 5000 & ≤ 5200	X+	2	15400	742.5	124	111	97	300	1471	8	200	686
> 5200 & ≤ 5500	Y+	2	16100	742.5	127	111	97	300	1471	8	200	696
> 5500 & ≤ 5800	Z+	2	16900	742.5	130	114	100	300	1471	8	200	706
> 5800 & ≤ 6100	A*	2	17800	742.5	132	117	102	300	1471	8	200	706
> 6100 & ≤ 6500	B*	2	18800	742.5	137	120	107	300	1471	9	200	716
> 6500 & ≤ 6900	C*	2	20000	770		124	111	300	1471	9	200	726
> 6900 & ≤ 7400	D*	2	21500	770		127	114	300	1471	10	200	726
> 7400 & ≤ 7900	E*	2	23000	770		132	117	300	1471	11	200	726
> 7900 & ≤ 8400	F*	2	24500	770		137	122	300	1471	11	200	735
> 8400 & ≤ 8900	G*	2	26000	770		142	127	300	1471	12	200	735
> 8900 & ≤ 9400	H*	2	27500	770		147	132	300	1471	13	200	735
> 9400 & ≤ 10000	I*	2	29000	770		152	132	300	1471	14	200	735
> 10000 & ≤ 10700	J*	2	31000	770			137			15	200	735
> 10700 & ≤ 11500	K*	2	33000	770			142			16	200	735

Table 3.2.2 (Contd.)

EN	Equipment letter	Stockless bower anchors		Stud-link chain cables for bower anchors				Towline (Recommendation)		Mooring lines [1]		
				Total length [m]	Diameter and grade			Steel or natural fibre ropes				
		Number	Mass per anchor [kg]		CC1 [mm]	CC2 [mm]	CC3 [mm]	Min. length [m]	Min. breaking strength [kN]	Number	Length of each [m]	Min. breaking strength [kN]
> 11500 & ≤ 12400	L*	2	35500	770			147			17	200	735
> 12400 & ≤ 13400	M*	2	38500	770			152			18	200	735
> 13400 & ≤ 14600	N*	2	42000	770			157			19	200	735
> 14600 & ≤ 16000	O*	2	46000	770			162			21	200	735

1) For individual mooring lines with required breaking force above 490 [kN] according to the table, the required strength may be reduced by the corresponding increase of the number of mooring lines and vice versa, provided that the total of all mooring lines on board is not less than the Rule value. However, the number of mooring lines is not to be less than 6, and no line is to have a breaking force less than 490 [kN].

Section 4

Anchors

4.1 General

4.1.1 Anchors are to be of an approved design.

4.1.2 The mass of each bower anchor as required in Sec.3 is for anchors of equal mass. The masses of individual anchors may vary by ±7 per cent of the tabular masses, provided that the total mass of the anchors is not less than would have been required for anchors of equal mass.

4.1.3 The mass of the head, including pins and fittings, of an ordinary stockless anchor is not to be less than 60 per cent of the total mass of the anchor.

4.1.4 The mass 'ex stock' of stocked bower or stream anchors is not to be less than 80 per cent of the tabular mass of ordinary stockless bower anchors. The mass of the stock is to be 25 per cent of the total mass of the anchor including the shackle etc. but excluding the stock.

4.1.5 When anchors of a design approved for the designation 'High Holding Power' or 'Super High Holding Power' are used as bower anchors, the mass of each such anchor may be 75 percent or 50 percent respectively of the tabular mass of ordinary stockless bower anchors.

4.1.6 Anchor shackles are to be of a design and material suitable to the service for which the anchor is intended.

4.2 High Holding Power (HHP) anchors

4.2.1 Designs of H.H.P. anchors are to be approved for the designation.

H.H.P. anchors are to be designed for effective hold of the sea bed irrespective of the angle or position at which they first settle on the sea bed after dropping from a normal type of hawse pipe. In case of doubt a demonstration of these abilities may be required. The designs are to be tested on sea bed to show that they have a holding down power per unit of mass at least twice that of approved ordinary stockless anchor.

4.2.2 If approval is sought for a range of anchor sizes, at least two sizes are to be tested. The mass of the larger anchor to be tested is not to be less than one-tenth of that of the largest anchor of which approval is sought. The smaller of the two anchors to be tested is to have a mass not less than one-tenth of that of the larger.

Each test is to comprise of a comparison between the H.H.P. anchor and at least one approved ordinary stockless anchor of nearly equal mass.

Anchors are to be tested in association with the size of chain cable appropriate to this mass.

4.2.3 The tests are to be conducted on at least three different types of bottom, which should normally be soft mud or silt, sand or gravel, and hard clay or similarly compacted material. Three tests are to be taken for each anchor and each type of bottom.

The tests should normally be carried out from a tug, and the pull measured by dynamometer or derived from recently verified curves of tug rev/min against bollard pull.

A scope of ten is recommended for the anchor cable.

4.3 Super High Holding Power (SHHP) anchors

4.3.1 A super high holding power anchor is an anchor with a holding power of at least four times that of an ordinary stockless anchor of the same mass. The use of SHHP anchors is to be limited to vessels with service restrictions given in Pt.1, Ch.1, Sec. 2.7.3. These anchors are not to require prior adjustment or special placement on the sea bed.

The SHHP anchor mass should generally not exceed 1500 [kg].

4.3.2 For approval and/or acceptance as a SHHP anchor satisfactory full scale tests are to be made confirming that the anchor has a holding power of at least four times that of an ordinary stockless anchor or at least two times that of a previously approved HHP anchor, of the same mass. The tests are also to verify that the anchor withstands the test without permanent deformation.

4.3.3 The full scale tests are to be carried out at sea as specified in 4.2.3 for HHP anchors, on three types of bottom. The tests are to be applied to anchors of mass which are as far as possible representative of the full range of sizes proposed.

For a definite group within the range, the two anchors selected for testing (ordinary stockless and SHHP anchors) should be approximately the same mass and should be tested in association with the size of chain required for the anchor mass and anchor type. Where an ordinary stockless anchor is not available, a previously approved HHP anchor may be used in its place.

Tests in comparison with a previously approved SHHP anchor may be also accepted as a basis for approval.

If approval is sought for a range of anchor sizes then at least three anchor sizes are to be tested, indicative of the bottom middle and top of the mass range.

4.3.4 The holding power test load is not to exceed the proof load of the anchor.

4.4 Manufacture and testing

4.4.1 Anchors and anchor shackles are to be manufactured and tested in accordance with the requirements of Pt.2, Ch.10.

Section 5

Anchor Chain Cables

5.1 General

5.1.1 Anchor chain cables and steel wire ropes (where proposed in lieu of chain cables) are to be as required by Sec.3.

5.1.2 Grade CC3 chain cable is to be used only when diameter is 20.5 [mm] or more.

5.1.3 Grade CC1 chain cable having material tensile strength of less than 400 [N/mm^2] is not to be used in association with high holding power or super high holding power anchors.

5.1.4 When the vessel may anchor where the current exceeds 2.5 m/s, a length of heavier chain cable locally between the anchor and the rest of the chain to enhance anchor bedding is recommended.

5.2 Manufacture and testing

5.2.1 Chain cables, steel wire ropes and shackles are to be manufactured and tested in accordance with the requirements of Pt.2, Ch.10.

Section 6

Towlines, Mooring Lines and associated Shipboard Fittings

6.1 General

6.1.1 Towlines and mooring lines may be of steel wire, natural fibre or synthetic fibre and are to be made by an approved manufacturer.

6.1.2 The number, length and breaking strength of towlines and mooring lines are to be as required by Sec.3. Also see 1.1.2.

6.1.3 The lengths of individual mooring lines may be reduced by up to 7 per cent of the tabular length, provided that the total length of mooring lines is not less than would have resulted had all lines been of equal tabular length.

6.1.4 The diameter of a fibre rope is not to be less than 20 [mm].

6.2 Manufacture and testing

6.2.1 Steel wire ropes are to be manufactured and tested in accordance with the requirements of Pt.2, Ch.10.

6.2.2 Fibre ropes will be specially considered in each case.

6.3 Towing and Mooring arrangements

6.3.1 Means are to be provided to enable towing lines and mooring lines to be adequately secured on board a ship. Bollards and bitts, fairleads, chocks, cleats, etc. are to be so designed and installed as to protect ropes against excessive wear.

These shipboard fittings associated with the towing and/or mooring, operations at bow, sides and stern are to comply with the requirements given in 6.4 and 6.5. For ships below 500 GT, special consideration may be given if considered necessary for practical/operational reasons.

6.3.2 Oil tankers, chemical tankers and liquefied gas carriers are also to comply with the requirements of emergency towing arrangements given in Pt.5, Ch.2, 3 and 4 as applicable.

6.3.3 Mooring winches should be fitted with drum brakes, the strength of which is sufficient to prevent unreeling of the mooring line when the rope tension is equal to 80 per cent of the breaking strength of the rope as fitted on the first layer on the winch drum.

6.4 Design loads

6.4.1 Where required, the minimum design loads to be considered for shipboard fittings and supporting hull structures are to be as follows:

a) For normal towing operations (e.g. harbour / manoeuvring), 1.25 times the intended maximum towing load (e.g.

static bollard pull) as indicated on the towing and mooring arrangement plan.

b) For other towing operations (e.g. escort), the nominal breaking strength of the tow-line as required in Table 3.2.2 corresponding to the equipment number of the vessel as per 3.1.1. While calculating equipment number for this purpose, the side projected areas including maximum stacks of deck cargoes are to be taken into account in the estimation of area 'A'.

c) For mooring operations, 1.25 times the breaking strength of the mooring line as required in Table 3.2.2 corresponding to the equipment number of the vessel as per 3.1.1. However, side projected area including maximum stacks of deck cargoes is to be taken into account for assessment of lateral wind forces, arrangement of tug boats and selection of mooring lines.

6.4.2 The design load is to be applied through the tow line / mooring line according to the arrangement shown on the towing and mooring arrangements plan

6.4.3 When a specific SWL (Safe Working Load) is applied for a shipboard fitting by which the design load will be greater than the above minimum values, the strength of the fitting is to be designed using this specific design load.

6.4.4 The method of application of the design load to the fittings and supporting hull structures is to be taken into account such that the total load need not be more than twice the design load, i.e. no more than one turn of one line (see Fig.6.4.4).

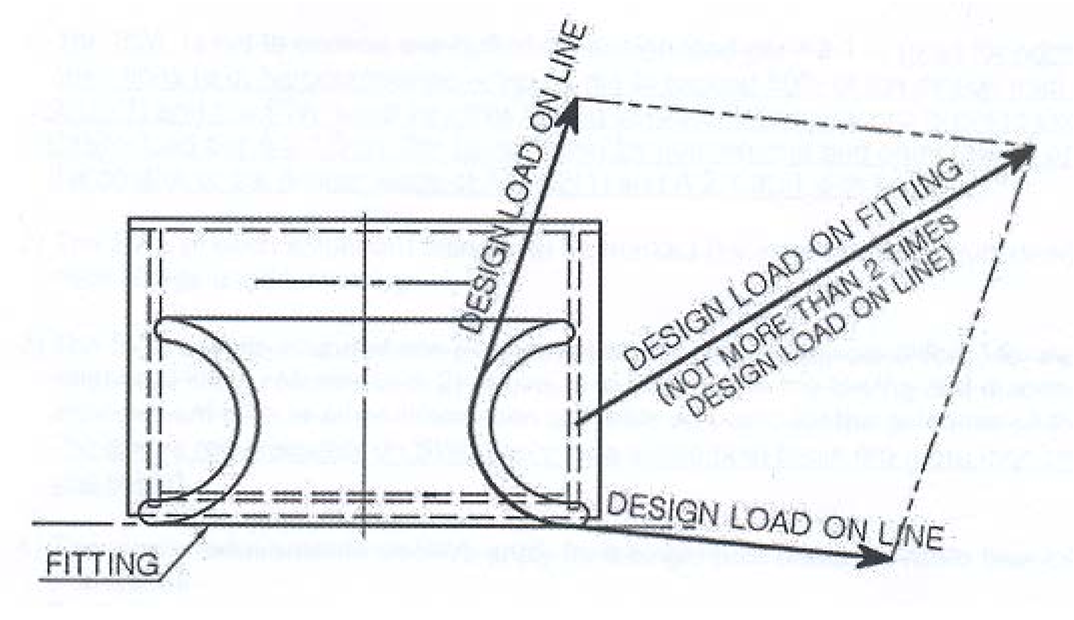


Fig.6.4.4

6.5 Shipboard fittings

6.5.1 The shipboard fittings associated with towing and/or mooring, including their welded or bolted connections to the supporting structure, are to be in accordance with a recognized standard, e.g. ISO 13795 Ships and Marine Technology – Ship's mooring and towing fittings – welded steel bollards for sea-going vessels. Alternatively, the strength of the fittings and its attachment is to be proved adequate for the design load specified in 6.4:

6.5.2 Shipboard fittings are to be suitably located on longitudinals, beams and/or girders so as to facilitate efficient distribution of the towing and/or mooring loads.

6.5.3 The net scantlings of the underdeck supporting structure are to be adequate to meet the design loads specified in 6.4.1, considering the possible locations for transfer of the load and any horizontal or vertical variation in direction of the applied load. The acting point of the force on the shipboard fittings is to be taken at the attachment point of the towing/mooring line or at a change in its direction.

Allowable stresses given below are not to be exceeded:

Normal stress = σ_y

Shear stress, $\tau = 0.6\ \sigma_y$

Where σ_y = specified minimum upper yield stress [N/mm^2];

Normal stress is the sum of the bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress.

Stress concentration factors are not to be taken into account in the above allowable stresses.

The required gross thickness is obtained by adding a corrosion addition of 2.0 [mm] to the net scantling except for oil tankers and bulk carriers covered by the common structural rules, where the corrosion additions specified in those rules would be applicable.

6.5.4 The safeworking load SWL for normal towing operations (e.g. harbour / manoeuvring) is not to exceed 80% of the design load as per 6.4.1a) and that for other towing operations (e.g. escort) is not to exceed the design load as per 6.4.1b).

For mooring operations, the SWL is not to exceed 80% of the design load as per 6.4.1c).

The above requirements on SWL apply for a single post basis (no more than one turn of cable).

The safe working load SWL of each shipboard fitting is to be marked (by weld bead or equivalent).

6.5.5 Towing and mooring arrangement plan

The SWL for the intended use for each shipboard fitting is to be noted in the towing and mooring arrangement plan available on board for the guidance of the Master.

Information provided on the plan is to include in respect of each shipboard fitting:

a) location on the ship;
b) fitting type;
c) SWL;
d) Purpose (mooring / harbour towing / escort towing); and
e) Manner of applying towing or mooring line load including limiting fleet angles.

Where the arrangements and details of deck fittings and their supporting hull structures are designed based on a variation of mooring arrangement (number of mooring lines and their individual strength) that is permitted as per Note 1 of Table 3.2.2, the following information is to be clearly indicated on the plan:

a) the arrangement of mooring lines showing number of lines (N), together with

b) the breaking strength of each mooring line (BS).

6.6 Emergency towing procedure

6.6.1 A ship specific emergency towing procedure is to be provided according to SOLAS Ch.II-1/Reg.3-4 on ships as indicated in the following:

a) all passenger ships, not later than 01 January 2010

b) cargo ships constructed on or after 01 January 2010

c) Cargo ships constructed before 01 January 2010, not later than 01 January 2012.

In the case of oil tankers, chemical carriers and liquefied gas carriers, the requirement for emergency towing arrangements given in Pt.5, Ch.2, Sec.2.8, Pt.5, Ch.3, IR2.8 and Pt.5, Ch.4, IR3.9 respectively are also to be complied with.

6.6.2 The emergency towing procedure is to be based on existing arrangements and equipment available on board the ship

6.6.3 The emergency towing procedure is to include:

a) drawings of fore and aft deck showing possible emergency towing arrangements;

b) inventory of equipment on board that can be used for emergency towing;

c) means and methods of communication; and

d) sample procedures to facilitate the preparation for and conducting of emergency towing operations.

(Refer to the IMO guidelines for owners / operators on preparing emergency towing procedures (MSC.1/Circ.1255)).

Section 7

Windlass and Chain Stoppers

7.1 General

7.1.1 Windlass of sufficient power and suitable for the size of chain cable is to be fitted. Where wire ropes are proposed and approved in lieu of chain cables, suitable winches capable of controlling wire rope at all times are to be fitted.

7.1.2 Windlass is to have one cable lifter for each anchor required to be kept ready for use. The cable lifter is normally to be connected to the driving shaft by release coupling and provided with brake.

7.1.3 For each chain cable, a chain stopper is normally to be arranged between the windlass and hawse pipe. The chain cables are to reach the hawse pipe through the cable lifter only.

7.1.4 Electrically driven windlasses are to have a torque limiting device. Electric motors are to comply with the requirements of Pt.4, Ch.8.

7.1.5 The windlass is to be capable of exerting, for a period of 30 minutes, a continuous duty pull corresponding to the grade of chain cable, as follows :-

36.8 d_c^2 [N]	for grade CC1
41.7 d_c^2 [N],	for grade CC2
46.6 d_c^2 [N]	for grade CC3

Where d_c is the chain diameter [mm]. The mean hoisting speed is not to be less than 9 [m]/min. Also See Sec. 7.2.1.

The windlass is to be also capable of exerting, for a period of not less than 2 minutes, a pull of not less than 1.5 times the continuous duty pull. The speed in this period can be lower.

The above criteria do not require both anchors to be raised or lowered simultaneously on windlass fitted with two cable lifters.

7.1.6 The capacity of the windlass brake is to be sufficient for safe stopping of anchor and chain cable when paying out.

The windlass with brakes engaged and release coupling disengaged is to be able to withstand static pull of 45 per cent of the tabular breaking strength of the chain without any permanent deformation of the stressed parts and without brake slip.

If a chain stopper is not fitted, the windlass is to be able to withstand a static pull of 80 per cent of the tabular breaking strength of the chain without any permanent deformation of the stressed parts and without brake slip.

The chain stoppers and their attachments are to withstand a pull of 80 per cent of the tabular breaking strength of the chain without any permanent deformation of the stressed parts. The chain stoppers are to be so designed that additional bending of the individual link does not occur and the links are evenly supported.

7.1.7 Attention is to be paid to stress concentrations in keyways and other stress raisers and also to dynamic effects due to sudden starting or stopping of the prime mover or anchor chain.

7.2 Strength of windlass securing arrangements to resist the green sea loads

7.2.1 In case of ships of length > 80 [m] the windlasses and mooring winches integral with the windlasses fitted on exposed decks in the forward 0.25L are to be adequately secured against the green sea loads given in 7.2.2, if the height of the exposed decks in way of the windlasses is less than 0.1L or 22 [m] above summer LWL. The strength criteria given in 7.2.3 is to be complied with.

7.2.2 Design loads

The following green sea pressures are to be considered:

- Pressure 'p_x' equal to 200 [kN/m^2], normal to the shaft axis as shown in Fig.7.2.2 and acting over the projected area in this direction.

- Pressure 'p_y' equal to 150 [kN/m^2], parallel to the shaft axis as shown in Fig.7.2.2 acting both inboard and outboard separately, over the multiple of 'f' times the projected area in this direction.

where 'f' is defined as:

f = 1+B/H, but need not be taken greater than 2.5

where,

B = width of windlass measured parallel to the shaft axis.

H = overall height of windlass.

7.2.3 For calculation of forces in the bolts securing the windlass to the deck, the bolts may be considered to be divided into 'N' bolt groups each containing one or more bolts. (See Fig.7.2.2).

The axial force R_i in bolt group (or bolt) i, positive in tensile, may be calculated from:

$R_{xi} = P_x\, hx_i\, A_i / I_x$
$R_yi = P_y\, hy_i\, A_i / I_y$

and $R_i = R_{xi} + R_{yi} – R_{si}$

where,

P_x = force [kN] acting normal to the shaft axis

P_y = force [kN] acting parallel to the shaft axis, either inboard or outboard whichever gives the greater force in bolt group 'i'

h = shaft height above the windlass mounting [cm]

x_i, y_i = x and y coordinates of bolt group 'i' from the centroid of all N bolt groups, positive in the direction opposite to that of the applied force [cm]

A_i = cross sectional area of all bolts in group 'i' [cm^2]

$I_x = \Sigma A_i x_i^2$ for N bolt groups
$I_y = \Sigma A_i y_i^2$ for N bolts groups

R_{si} = static reaction at bolt group 'i', due to weight of windlass.

Shear forces F_{xi}, F_{yi} applied to the bolt group 'i', and the resultant combined force F_i may be calculated from:

$F_{xi} = (P_x - \alpha gM) / N$
$F_{yi} = (P_y - \alpha gM) / N$

and

$$F_i = (F_{xi}^2 + F_{yi}^2)^{0.5}$$

where,

α = coefficient of friction = 0.5
M = mass of windlass (tonnes)
g = gravity acceleration = 9.81 m/sec^2
N = number of bolt groups.

Axial tensile and compressive forces and lateral forces are also to be considered in the design of the supporting structure.

7.2.4 Strength criteria

Tensile axial stresses in the individual bolts in each bolt group 'i' are to calculated. The horizontal forces F_{xi} and F_{yi} are normally to be reacted by shear chocks. Where "fitted" bolts are designed to support these shear forces in one or both directions, the von Mises equivalent stresses in the individual bolts are to be calculated and compared to the stress under proof load. Where pourable resins are incorporated in the holding down arrangements, due account is to be taken in the calculations.

The safety factor against bolt proof strength is to be not less than 2.0.

7.3 Testing

7.3.1 After installation on board, anchoring tests are to be carried out to demonstrate satisfactory working.

The mean speed of the chain cable measured during trials, when hoisting the anchor and cable from a depth of 82.5 [m] to a depth of 27.5 [m] is not to be less than 9 [m/min]. Where the depth of water in trial areas is inadequate, consideration will be given to acceptance of equivalent simulated conditions.

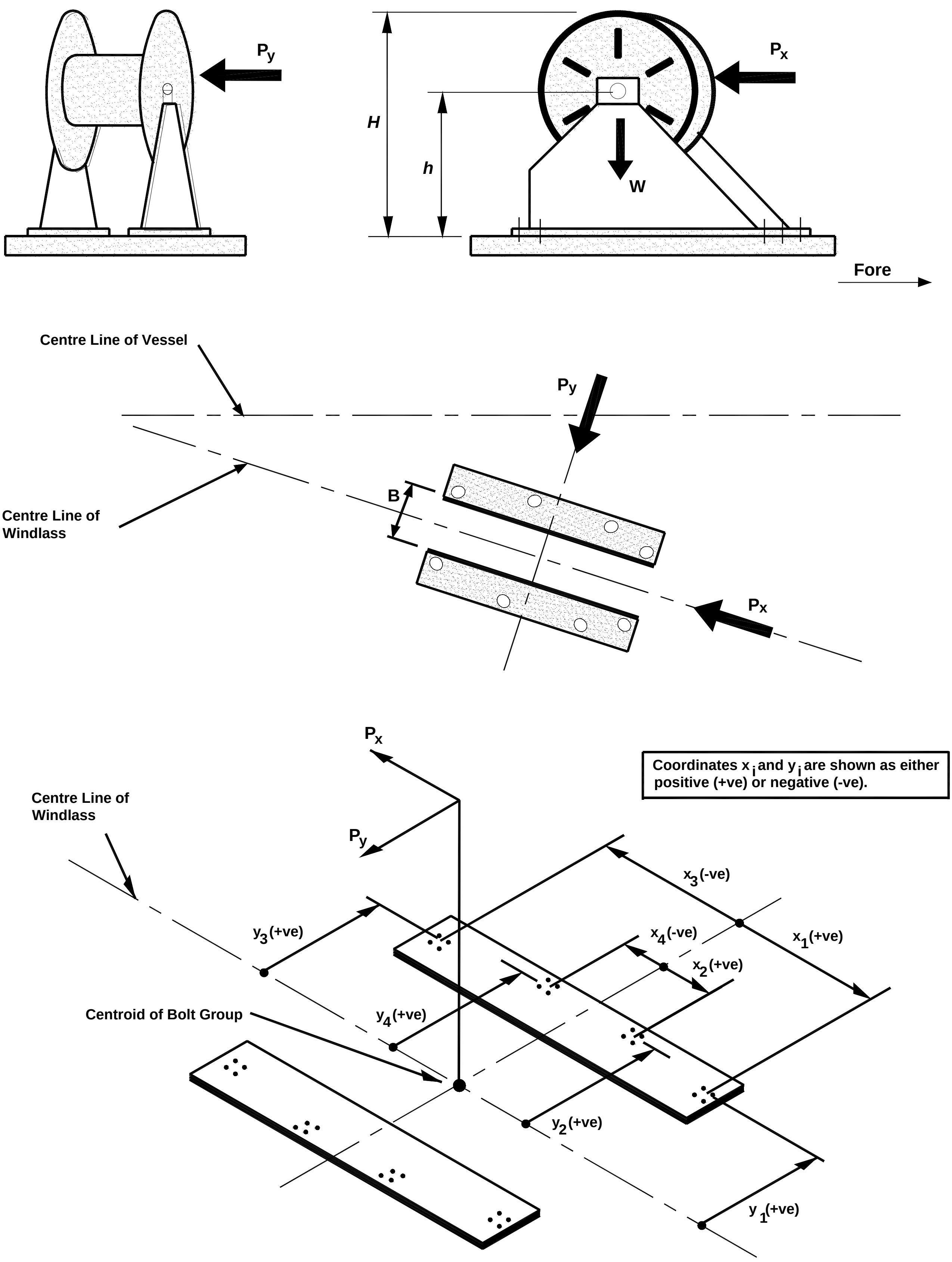


Fig.7.2.2 : Direction of forces and weight

End of Chapter

Chapter 16

Masts and Rigging

Contents

Section

Section 1

General

1.1 Application

1.1.1 Masts, derrick posts, crane pedestals etc. and their supporting hull structure are to be in accordance with the requirements of this Chapter. The derricks and the cargo handling gear, are not subject to approval unless required by additional class notations.

1.2 Documentation

1.2.1 The following plans and information are to be submitted:

i) Arrangement plan showing location of mast or derrick post, standing rigging and cargo handling gear alongwith the information about the operation of the derrick booms, their safe working load and working positions.

ii) Plan showing proposed scantlings of mast, derrick post and standing rigging.

iii) Plan showing supporting structures and strengthening of hull in way of mast, post and standing rigging fastenings,

iv) Specification of the steel wire ropes intended to be used for standing rigging, indicating rope construction, scantlings and minimum breaking strength.

1.2.2 Calculations considering the derrick booms at the operating position which results in maximum stresses on the mast, are to be submitted. For masts supporting derricks, angles of heel and trim of the ship in this condition of less than 5° and 2° respectively, may be ignored. Where these angles are exceeded, and in all cases where the mast supports derrick cranes or derricks of special design, the actual angles are to be taken into account in calculating the stresses in the mast. In case of stayed masts, the calculations are to take into account the elongation of the stays under tension.

1.2.3 For masts such as portal, bipod, lattice etc. and those under significant forces other than resulting from cargo gear; detailed stress calculations are to be submitted, taking into account:

i) All horizontal, vertical and torsional forces,
ii) Deflection of the structure,
iii) Variations in the moment of inertia of the parts of the structure,
iv) The effects of outriggers and similar structures,
v) Elasticity and sag in stays, where fitted.

1.3 Materials

1.3.1 Steel for masts, derrick posts, crane pedestals and associated items are to be tested and approved in accordance with the requirements of Pt.2, Ch.3. Material grades of steel are to be as follows:

Thickness [mm]	t ≤ 20	20 ≤ t < 25	25 ≤ t < 40	t > 40
Grade	A/AH	B/AH	D/DH	E/EH

1.3.2 Wire ropes used for stays are to be in accordance with the requirements of Pt.2, Ch.10.

Section 2

Masts

2.1 Scantlings

2.1.1 The outer diameter 'd' of the masts without derricks at the level of upper supporting deck is not to be less than:

d = 37 *l* [mm] for unstayed masts

= 33 *l* [mm] for stayed masts

where,

l = length of the mast [m] measured above upper supporting deck to hounds.

The diameter is to be maintained upto the level of the gooseneck fitting where this is entirely supported by the mast. In case of masts without derricks, the diameter may be reduced to 0.75 d at top.

2.1.2 For masts without derricks, the thickness 't' of the mast plating is not to be less than

t = 0.01d + 2.5 [mm] or 5 [mm] whichever is greater.

2.1.3 The scantlings of masts with derricks are to be based on calculations mentioned in 1.2.2 and 1.2.3. The total stress σ_t at any location, is not to exceed the allowable stress values given below:-

Allowable stresses in masts		
SWL	**Stayed mast**	**Unstayed mast**
SWL ≤ 10t	0.50 σ_y	0.55 σ_y
SWL ≥ 60t	0.625 σ_y	0.675 σ_y
10 < SWL < 60	By linear interpolation	

where,

$$\sigma_t = \sqrt{\left[(\sigma_b + \sigma_c)^2 + 3\tau^2\right]}\ [\mathrm{N/mm^2}]$$

σ_b = bending stress at that location.

σ_c = direct compressive stress at that location due to the vertical components of force. In general, the weight of the mast and cross trees may be ignored in this calculation.

τ = The shear stress due to torque in the mast. The effect of torque need only be considered where cross trees are fitted.

σ_y = Upper yield stress of the material [N/mm^2].

For the above Table, SWL corresponding to the largest derrick operating on the mast is to be taken.

The thickness of the mast plating is to be adequate to prevent buckling and in no case is to be less than 7.5 [mm].

2.2 Construction details

2.2.1 Masts are to be adequately supported by atleast two decks and are to be efficiently scarphed into the main hull structure. The hull structure is to be suitably reinforced. A deckhouse may be considered as a support provided adequate strength is ensured by additional stiffening and increased plate thickness.

2.2.2 In general, mast scantlings are not to be reduced inside the deckhouse and are to be maintained upto the level of the gooseneck fitting where it is entirely supported by the mast.

2.2.3 Cross trees, outriggers, brackets on bridge fronts and similar structures are to be of such design that the stresses on them resulting from the cargo gear and any other significant forces do not exceed the values given in 2.1.3 for unstayed masts. The design is also to be such as to minimize the moments acting on the mast. Attachment to the mast is to be such as to avoid distortion of the mast under the load.

2.2.4 Special attention is to be paid to structural continuity, and abrupt changes of section are to be avoided. Manholes, lightening holes and other cut outs are to be avoided in way of concentrated loads and areas of high shear. Openings, where unavoidable, are to be well rounded, suitably framed and stiffened.

2.2.5 Care should be taken in the design of masts and fittings to reduce the likelihood of water collecting in inaccessible parts of the structure. Adequate means of drainage should be provided to remove any water which might otherwise accumulate.

2.2.6 Masts are to be strengthened either by addition of doubling plates or equivalent strengthening, or by an increase of the thickness of the plating at the following locations:

i) In way of the fastening of the derrick heels,

ii) In way of the fastening of the derrick spans,

iii) In way of the fastening of all metal fittings.

Suitable arrangements are to be made to avoid notch effects.

2.2.7 Welding and weld details are to comply with Ch.17.

2.2.8 Where a mast supports a derrick with a SWL > 25 [t], all welded joints of the masts below a level 3.0 [m] above the uppermost supporting deck or that of the derrick head, whichever is higher, are to be examined by non-destructive crack or flaw detection method.

2.2.9 Where higher tensile steel is used, preheating or other heat treatments may be required at the Surveyors discretion. Such treatments will normally be required for all ring seams on masts supporting derricks of SWL > 60 [t]. Non-destructive examination may be required in areas of high stresses.

2.2.10 Lightning conductors are to be fitted to masts having wood, aluminium or plastic top masts or where a break in electrical conductivity occurs in other arrangements.

Section 3

Rigging

3.1 General

3.1.1 The positioning of the rigging (shrouds, stays etc.) is to be so designed as to ensure proper working of the cargo gear and that they do not foul with the running rigging or derrick booms under the expected service conditions.

3.1.2 Wire rope stays are to be in one length and are to be set up with an initial tension of 30 [N/mm^2].

3.2 Stay construction

3.2.1 The scantlings of the stay are to be such as to provide the necessary tensile force and elongation for the stayed mast. The breaking load of the stay is to be not less than 3.5 times the maximum calculated force on that stay.

3.2.2 The connection of the stay to a deck, bulwark, house or mast is to be such as to allow rotation at the point of attachment and is to be designed so that the stay cannot become disconnected while the derrick system is in use.

End of Chapter

Chapter 17

Welding

Contents

Section

Section 1

General

1.1 Scope

1.1.1 Welding in steel hull construction of all types of ships is to comply with the requirements of this Chapter.

Welding in aluminium structures will be specially considered.

1.2 Documentation

1.2.1 Connection details of the welded structural members, including type and size of welds are to be clearly indicated on the plans submitted for approval. An explanation of all symbols or abbreviations used in detailing the weld connections should be included on the plans.

Details of proposed welding procedure is to be submitted indicating preheating temperature and any post-welding heat treatment, if employed. Extent to which automatic welding, including deep penetration welding, is to be employed should also be indicated.

Section 2

Welding

2.1 Welders and supervision

2.1.1 Welders are to be proficient in the type of work on which they are to be engaged. The records of their tests and qualifications are to be kept by the builders and made available to the Surveyors. A sufficient number of skilled supervisors are to be employed to ensure effective control at all stages of assembly and welding operations.

2.2 Welding electrodes

2.2.1 Electrodes and welding consumables approved by IRS in accordance with the requirements of Pt.2, Ch.11 and suitable for the type of joint and grade of steel, are to be used.

2.2.2 For the connection of two different grades of steel of the same tensile strength properties, electrodes suitable for the lower grade will be generally acceptable except at structural discontinuities or other points of stress concentration.

2.2.3 For the connection of steel of different tensile strengths, the electrodes are to be suitable for the tensile strength of the component, on the basis of which the weld fillet size has been determined in Sec.3.

2.3 Preparation for welding

2.3.1 The parts to be welded are to be fitted in accordance with the approved joint detail. The edge preparation is to be accurate and uniform.

Means are to be provided for maintaining the parts to be welded, in correct position during the welding operations. Excessive force is not to be employed in aligning the parts before welding and the means employed in maintaining the alignment are to be so arranged as to allow for expansion and contraction during the welding operation. All methods employed in correcting improper alignment are to be to the satisfaction of the Surveyor.

2.3.2 All surfaces to be welded are to be clean, dry and free from rust, scale and grease. The surface and boundaries of each run of deposit are to be thoroughly cleaned and freed from slag before the next run is applied. Before a manual sealing run is applied to the back of a weld, the original root material is to be gouged out to sound metal.

2.3.3 Tack welding is to be kept to a minimum, and where used, should be equal in quality to that of the finished welds. Any defective tack weld is to be cut out before completing the finished welds. Care is to be taken in removing the tack welds to ensure that the structure is not damaged in doing so.

2.4 Welding procedure

2.4.1 Only approved welding procedures are to be used, See 2.5.

2.4.2 Structural arrangements are to be such as to allow adequate access for satisfactory completion of all welding operations. Welded joints are to be so arranged so as to facilitate downhand welding wherever possible.

2.4.3 The sequence of welding is to be so planned that any restraint during welding operations is reduced to a minimum. The ends of the frames and stiffeners should be left unattached to the plating at the subassembly stage until connecting welds are made, in the intersecting systems of plating, framing and stiffeners, at the erection stage.

Where a butt meets a seam, the welding of the seam should be interrupted well clear of the junction and not be continued until the butt is completed. Welding of the butt should continue past the open seam and the weld be chipped out for the seam to be welded straight through.

2.4.4 Adequate precautions are to be taken to ensure that the welding site is protected from the deleterious effects of high moisture, severe wind and extreme cold.

2.5 Approval of procedures

2.5.1 Unless previously approved, welding procedures are to be established by the yard and forwarded to IRS for approval. The welding procedure specifications are to include detailed description of the base material, primer, plate thickness range, joint/groove design, welding consumable, welding position, welding techniques, welding parameters, preheating/ interpass temperature and post heat treatment if any.

The welding for procedure qualification and subsequent testing, are to be witnessed by the IRS Surveyor.

2.6 Inspection of welds

2.6.1 Effective arrangements are to be provided for the inspection of finished welds to ensure that all welding has been satisfactorily completed.

2.6.2 All finished welds are to be visually inspected and are to be sound, uniform and substantially free from slag inclusions, porosity, undercutting or other defects. Welds and adjacent base metal are to be free from injurious arc strikes.

2.6.3 For the examination of important structural welds, visual inspection is to be supplemented by radiography or other acceptable non-destructive crack or flaw detection methods. The extent of such examination is to be to the Surveyors' satisfaction, but particular attention is to be given to the following locations:

a) Junction and crossings of seams and butts in strength deck, sheer strake, side and bottom shell within 0.4L amidships.

b) Butts of keel plating and rounded sheerstrake within 0.4L amidships.

c) Insert plates in way of hatch openings on the strength deck.

d) Butts of longitudinal framing and longitudinal bulkhead stiffeners within 0.4L amidships.

2.6.4 Defective sections of welds as found by visual or non- destructive examination or leakages under hydrostatic tests, are to be gouged out as necessary and carefully rewelded.

Section 3

Welded Connections

3.1 Butt welds

3.1.1 Plates of equal thickness may be manually butt welded as per Fig.3.1.1. For automatic welding procedures and special welding techniques, the welding procedure will be specially considered.

3.1.2 For joints of plates with difference in thickness of more than 4 [mm], the thicker plate is to be tapered. The taper is not to exceed 1:3. Edge preparation after the tapering is to be as indicated in 3.1.1 above.

3.1.3 All manual butt welds are normally to be welded from both sides. Where a back ceiling run is not practicable or in certain cases when the stress level in the members is very low, welding on one side may be permitted provided the welding process is found satisfactory.

3.1.4 Where stiffening members, attached by continuous fillet welds, cross the finished butt or seam welds, these welds are to be made flush in way of the faying surface. Similarly for butt welds in webs of stiffening members, the butt weld is to be first completed and made flush with the stiffening member before the stiffener is connected to the plating by fillet weld. The ends of the flush portion are to run out smoothly without notches or any sudden change of section. Where such conditions can not be complied with, a scallop is to be arranged in the web of the stiffening member. Scallops are to be of such size and in such a position, that a satisfactory weld can be made.

3.2 'T' connections

3.2.1 The throat thickness (See Fig.3.2.1) of the fillet welds is given by:

throat thickness = t_p . weld factor . d/s

where,

t_p = thickness [mm], of the thinner of the two parts being connected.

d = distance [mm], between the successive weld fillets.

s = length [mm], of the correctly proportioned weld fillets, clear of end craters is not to be less than 75 [mm].

The weld factors for various connections are generally to be as given in Table 3.2.1.

Where an approved automatic deep penetration procedure is used, the weld factors may be reduced by 15 per cent.

3.2.2 The throat thickness is not to be less than 3.0 [mm] for t_p upto 8.0 [mm] and 0.21 t_p or 3.25 [mm], whichever is greater, for t_p over 8 [mm]. The throat thickness is also generally not to be greater than 0.44 t_p for double continuous welds and the greater of 0.44 t_p or 4.5 [mm] for intermittent welds.

3.2.3 The leg length is not to be less than √2 times the specified throat thickness.

3.2.4 Where the connection is highly stressed, deep penetration or full penetration welding may be required. Where full penetration welding is required, the abutting plate may require to be beveled. (See Fig.3.2.4).

3.2.5 Continuous welding is to be adopted in the following locations and may be used elsewhere if desired.

a) Boundaries of weathertight decks and erections, including hatch coamings, companionways and other openings.

b) Boundaries of tanks and watertight compartments.

c) All structures in the afterpeak and the afterpeak bulkhead stiffeners.

d) All welding inside tanks intended for chemicals or edible liquid cargoes.

e) All lap welds in tanks.

f) Floors and girders to bottom shell in the 0.25L forward.

g) Primary and secondary members to plating in way of end connection and end brackets to plating in the case of lap connection.

h) Where the thickness of the abutting member (i.e. stiffener web) is greater than 15 [mm] and also exceeds the thickness of the table member (e.g. plating).

i) Where loading is mainly of dynamic nature (e.g. bottom and side plating forward subjected to slamming and bow impact).

j) Other connections as given in Table - 3.2.1.

3.2.6 Where intermittent welding is used, the welding is to be made continuous around the ends of brackets, lugs, scallops and at other orthogonal connections with other members. Where intermittent welding is permitted as per Table 3.2.1, only scalloped welding is to be used in tanks for water ballast, cargo oil or freshwater.

Chain or staggered intermittent welding may be used in dry spaces or tanks arranged for fuel oil only.

3.2.7 Where structural members pass through the boundary of a tank, and leakage into the adjacent space could be hazardous or undesirable, full penetration welding is to be adopted for the members for at least 150 [mm] on each side of the boundary. Alternatively, a small scallop of suitable shape may be cut in the member close to the boundary outside the compartment, and carefully welded all round.

3.3 Lap connections

3.3.1 Overlaps are not to be used to connect plates which may be subjected to high strength or compressive loading. However, where they are adopted, the width of overlap is to be adequate to ensure a good weld, the surfaces are to be in close contact and the joints should be closed all round by continuous fillet weld.

3.4 Slot weld

3.4.1 For the connection of plating to internal webs, where access for welding is not practicable, the closing plating is to be attached by continuous full penetration or slot welds to flat bars fitted to the webs. Slots are to be well rounded at ends, to have a minimum length of 75 [mm] and in general, a minimum width of twice the plating thickness. The distance between the slots is not to exceed 150 [mm]. Complete filling of the slots is normally not permitted.

3.5 End connection

3.5.1 In way of the end connections of girders double continuous welding is to be used all around. The weld area is not to be less than the cross-sectional area of the member, and the throat thickness not less than that given by Table 3.2.1 for girder ends.

3.5.2 Where stiffeners have bracketed end connections, bracket arms are to be welded all around and the throat thickness is not to be less than 0.35 times the thickness of bracket.

3.5.3 Where stiffeners are continuous at girder, they are to be connected to the webs, either directly and/or by means of lugs. The weld area is to be such that the shear stress does not exceed 80/k [N/mm^2]. Where the shear forces are high, a double sided connection to the web and/or a web stiffener welded on top of the continuous stiffener may be required.

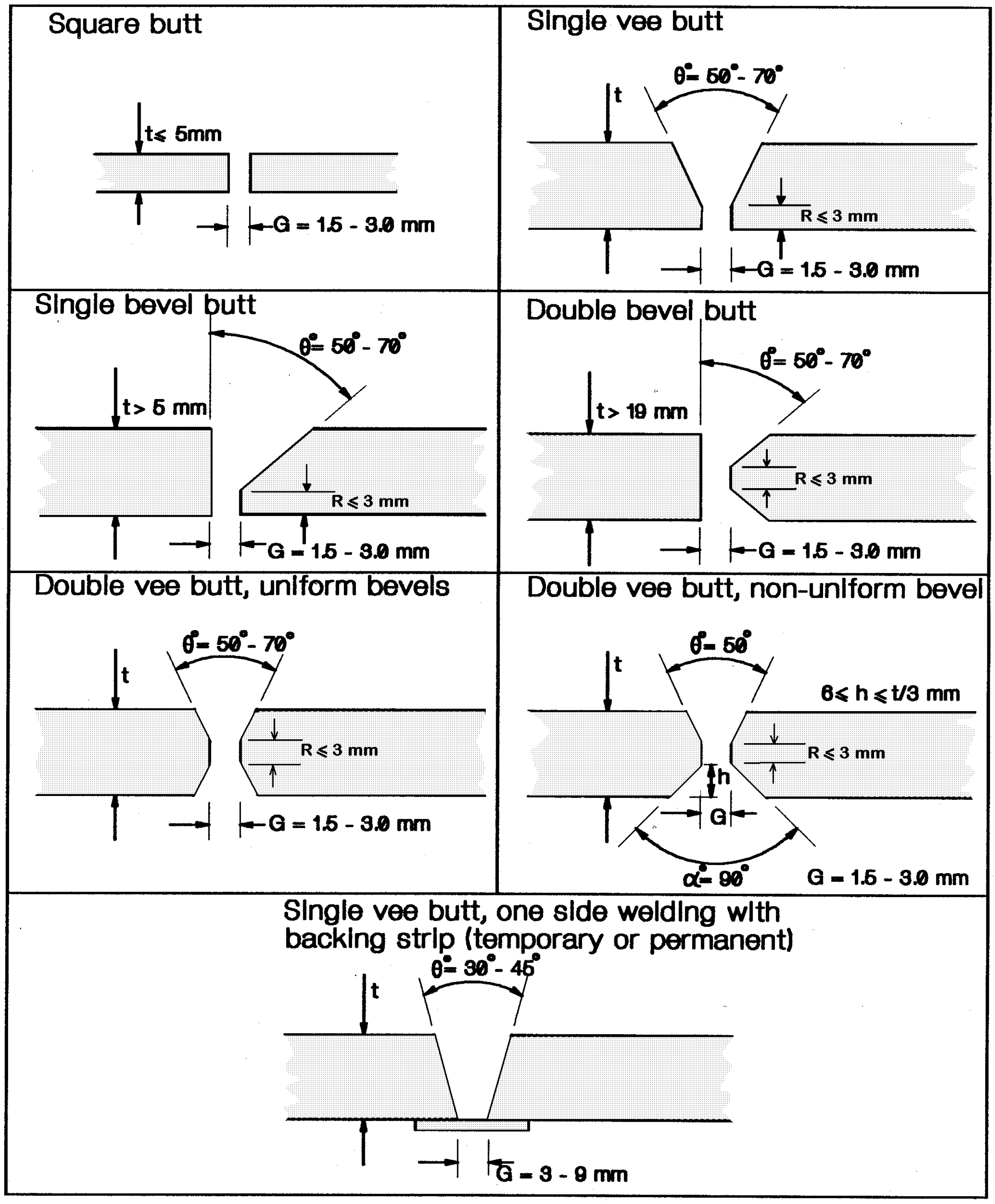


Fig.3.1.1 : Typical manually welded butt joints

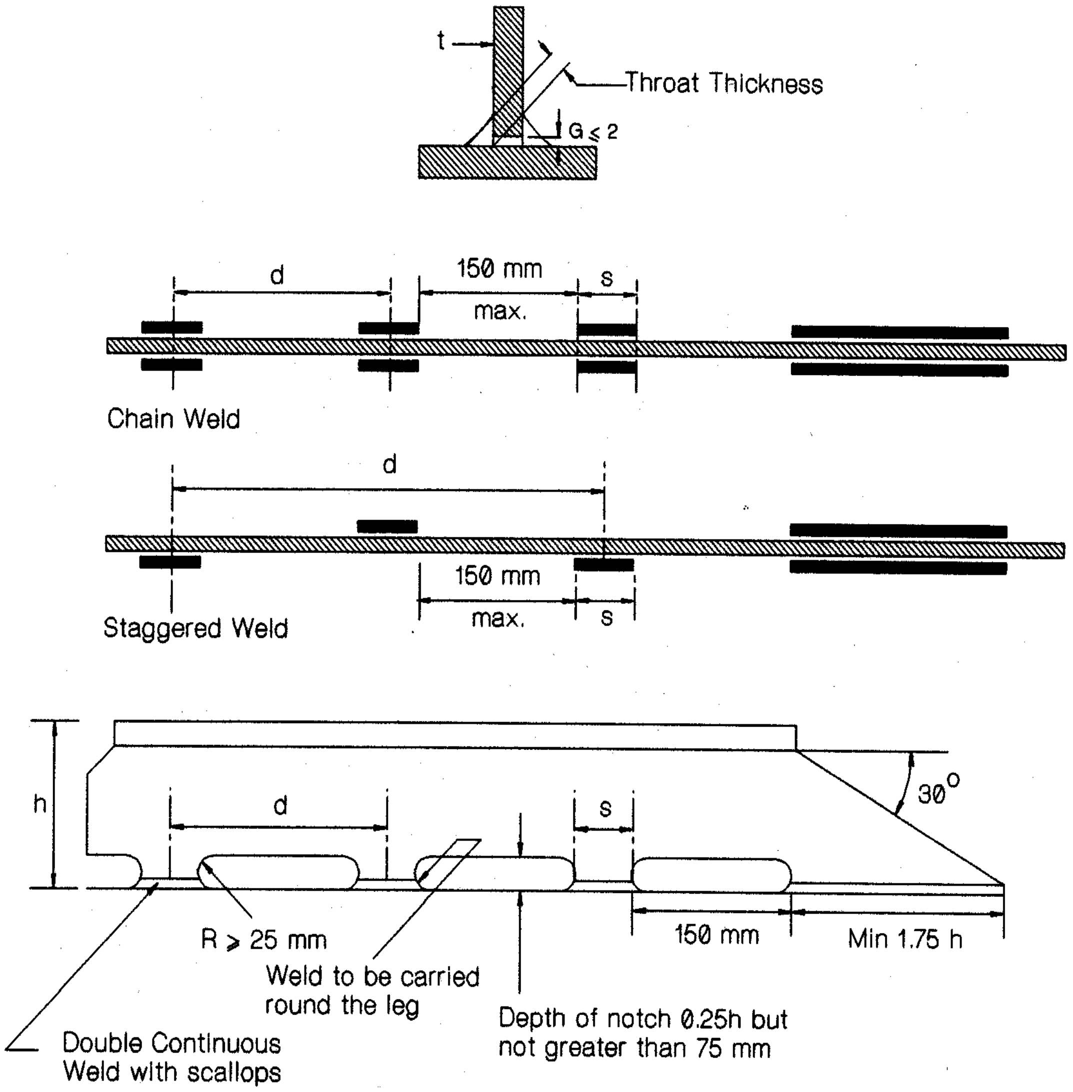


Fig.3.2.1 : Intermittent fillet welds

Table 3.2.1 : Weld factors for fillet welds

	Structural Items	Weld Factors	Permitted type of weld		Remarks
			Double cont.	Intermi-ttent	
Single Bottom					
Centre girder	To keel plate or bar keel	0.3	*		
	To face plate	0.15		*	
Side girder	To bottom shell	0.15		*	
	To face plate	0.13		*	
	To floors	0.20		*	
Floors	To keel plate	0.15	*		
	To shell plating	0.15		*	
	To centre girder	0.35	*		
	To longitudinal bulkheads	0.35	*		
	To face plate	0.15		*	
	Stern-tube covering	0.15	*		
Bottom longitudinal	To shell plating	0.13		*	
Double Bottom (See Note 1)					
Centre girder or duct keel	To keel plate	0.3	*		
	To inner bottom	0.25		*	
Side girder	To bottom shell	0.15		*	
	To inner bottom	0.15		*	
	To floors	0.15		*	
Floors	To shell plating	0.15		*	
	To inner bottom/margin plate	0.15		*	
	To centre girder/keel plate	0.20		*	
Margin plate	To shell plating	0.4	*		
	To inner bottom	0.4	*		
Inner bottom	To side shell	0.4	*		
Tank side brackets	To shell plating	0.3		*	
	To margin plate	0.3		*	
Bracket floor	To inner bottom/bottom shell	0.15		*	
	To centre girder	0.25		*	
	To side shell/margin plate	0.25		*	
Bottom frames	To shell plating	0.13		*	
Reverse frames	To inner bottom	0.13		*	
Longitudinals	To shell plating	0.13		*	
	To inner bottom	0.13		*	
Tank boundaries and bilge wells		0.40	*		
Stiffeners	To floors and girders	0.13		*	

Table 3.2.1 : Weld factors for fillet welds (Contd.)

	Structural Items	Weld Factors	Permitted type of weld		Remarks
			Double cont.	Intermi-ttent	
Structure in Machinery Space					
Floors and girders	To shell and inner bottom	0.3	*		
	To face plate	0.2		*	
Transverse and longitudinal frames	To shell plating	0.15		*	
Floors	To centre girder in way of engine, thrust blocks and boiler seatings				
	- in single bottom	0.50	*		
	- in double bottom	0.30	*		
Main engine foundation girders	To top plate	0.5	*		See Note 2
	To hull structure	0.4	*		
Floors	To engine girder	0.4	*		
Brackets etc.	To engine girders	0.3	*		
Side Structure					
Transverse frames	To side shell				
	- in tanks	0.13		*	
	- elsewhere	0.11		*	For bulk carriers see Pt.5, Ch.1, Sec.2.5
Side longitudinals	To shell plating	0.13		*	
Web frames and side stringers	To shell plating				
	- within 0.2 x span from ends	0.35	*		
	- elsewhere	0.20		*	
	To face plate and tripping bracket	0.15		*	
Web frames	To side stringers	0.3	*		
Deck Structure					
Strength deck	To shell	F.P.			See Note 3
Other decks	To shell and bulkheads	0.3	*		Generally
Deck beams	To deck plating				
	- in tanks	0.13		*	
	- elsewhere	0.11		*	
Deck longitudinals	To decks	0.13		*	
Deck girders	To deck plating				
	- within 0.2 x span from ends	0.35	*		
	- elsewhere	0.20		*	
	To face plating and tripping brackets	0.15		*	
Cantilever webs	To shell, decks, face plates and longitudinal girders at ends	0.35	*		
Pillars	To deck, inner bottom and pillar brackets	0.40	*		

Table 3.2.1 : Weld factors for fillet welds (Contd.)

	Structural Items	Weld Factors	Permitted type of weld		Remarks
			Double cont.	Intermi-ttent	
Construction in 0.25L from F.P.					
Floors and girders	To shell	0.25	*		
	To inner bottom	0.25		*	
Bottom longitudinals	To shell	0.15		*	
Shell	To transverse and longitudinal	0.15		*	
Panting stringers	To shell and frames	0.30	*		
All internal structure	In fore peak (unless a higher factor is specified)	0.13		*	
Aft Peak Construction					
All internal structure	On bottom, side shell and aft peak bulkhead	0.3	*		See 3.2.5
Bulkheads and Partitions					
Boundaries of	Watertight, oiltight and wash bulkheads and shaft tunnels	0.4	*		To be specially considered for chemical cargo tanks
Stiffeners	On tank and wash bulkheads	0.13		*	
	On pillar bulkheads	0.13		*	
	On ordinary bulkheads	0.11		*	
Vertical and horizontal girders in tanks and wash bulkheads	To bulkhead plating				
	- within 0.2 x span from ends	0.40	*		
	- elsewhere	0.30		*	
	- to faceplace	0.30		*	
	- to tripping brackets	0.15		*	
Vertical and horizontal girders elsewhere	To bulkhead plating				
	- within 0.2 x span from ends	0.35	*		
	- elsewhere	0.20		*	
	To faceplate and tripping brackets	0.15		*	
Primary Structures in Cargo Tanks					
Webs	To shell, deck and bulkheads				
	- within 0.2 x span from ends	0.4	*		
	- elsewhere	0.3	*	*	See 3.2.6
Webs	To face plates	0.3	*	*	"
Webs	To webs of other primary members	0.3	*		
Boundaries of	Tripping brackets	0.15	*	*	"
Superstructures and Deck Houses					
External bulkheads	To deck				
	- on 1st and 2nd tiers	0.40	*		
	- elsewhere	0.25	*		
Internal bulkheads	Boundaries	0.13		*	
stiffeners	To external bulkheads	0.10		*	See Note 4

Table 3.2.1 : Weld factors for fillet welds (Contd.)

	Structural Items	Weld Factors	Permitted type of weld		Remarks
			Double cont.	Intermi-ttent	
Hatchways and Closing Appliances					
Hatch coaming	To deck at corners	0.5	*		
	To deck elsewhere	0.4	*		
	To face plate	0.4	*		
	To hatch cover rest bar	0.16	*		
Hatch cover	To stiffeners	0.12		*	
Rudders and Nozzles					
Rudders					See Note 5
Main piece members	To coupling flange	F.P.	*		
	To each other	0.44	*		
Rudder plating	To rudder webs, elsewhere	0.20	*		
Nozzles	Generally as for rudders				
Miscellaneous Fittings and Equipment					
Framing ring for manhole type covers	To deck and bulkhead	0.4	*		
Framing around ports and W.T./oiltight doors	To plating	0.4	*		
Sea-chest boundary welds	Exposed to sea	0.5	*		
	Elsewhere	0.4	*		
Ventilators, air pipes etc.	To deck	0.4	*		
Bulwark stays	To deck	0.4	*		
	To bulwark plating	0.2		*	
Bilge keel	To ground bars	0.2	*	*	
Bilge keel ground bar	To side shell	0.35	*		Continuous fillet weld of minimum 4 [mm] throat thickness
Fabricated anchors		F.P.			
Masts, derrick posts, crane pedestals, deck machinery and mooring equipment seating - to deck etc.		To be considered in each individual case			

Intermittent welding means chain intermittent, staggered intermittent or scalloped welding with rounded ends.
For permitted use see 3.2.6.

F.P. means Full Penetrant weld

Note 1 For tank boundaries see 3.2.5. Where intermittent fillet welding of internals is proposed, see 3.2.6.

Note 2 Preferably to be deep penetration or full penetration weld depending on the thickness of the engine girders.

Note 3 Generally full penetration, but alternative proposals may be considered depending on t_p.

Note 4 For end connections see Chapter 11, 3.1.4.

Note 5 See Chapter 14, Section 4.1.

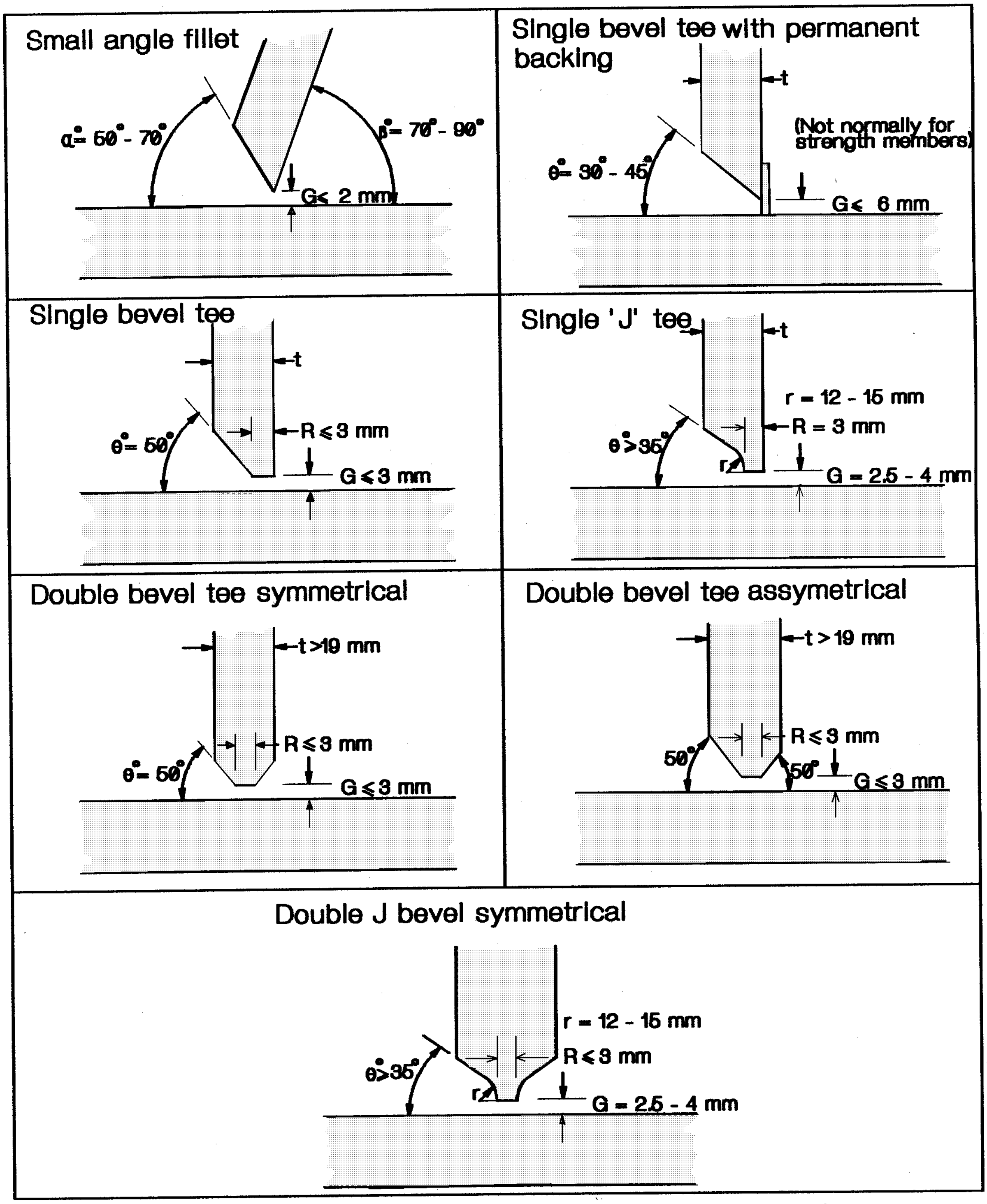


Fig.3.2.4 : Typical edge preparations for manually welded 'T' or cross joints

End of Chapter

Chapter 18

Hull Inspection, Workmanship and Testing

Contents

Section 1

Hull Inspection

1.1 Approval of works

1.1.1 The builders, intending to class vessels to be built at their yard with IRS, are to demonstrate their capability to carry out the fabrication to acceptable quality standards before the commencement of the fabrication. Similar approval procedure shall apply to subcontractor's works also. Previous experience in the building and repair of relevant structures and equipment can be considered favourably in this regard.

1.2 Inspection facilities

1.2.1 Adequate facilities are to be provided to enable the Surveyor to carry out a satisfactory inspection of all components during each stage of prefabrication and construction.

Section 2

Workmanship

2.1 General

2.1.1 All workmanship is to be of good quality and in accordance with good shipbuilding practice. Any defect is to be rectified to the satisfaction of the Surveyor before being covered with paint, cement or other composition.

2.1.2 The assembly sequence and welding sequence are to be agreed prior to construction and are to be to the satisfaction of the Surveyor.

2.2 Plate edges and cut-outs

2.2.1 Openings, holes and other cut-outs in the main structural components are to be rounded off by adequately large radii. The free edges of cut-outs, hatch corners etc. are to be properly prepared and are to be free from notches. All edges should be faired.

2.3 Cold forming

2.3.1 Flanging and bending of plates while cold forming are not to have an average bending radius less than three times the plating thickness. The minimum radius is not to be less than twice the plating thickness.

2.3.2 During joggling of plates and profiles, the depth of joggle is not to be less than four times and the bending radius not less than twice the web thickness.

2.4 Hammering, bending and straightening

2.4.1 Steel being worked on when hot, is not to be overheated, and it is to be hammered and bent in the appropriate heat condition. Steel which is burnt, is not to be used.

2.4.2 Flame heating may be employed to straighten buckled plating when the buckling is not severe.

Section 3

Testing of Tanks and Tight Boundaries

3.1 General

3.1.1 These test procedures are to confirm the watertightness of tanks and watertight boundaries and the structural adequacy of tanks which consist of the watertight subdivisions of ships. These procedures may also be applied to verify the weathertightness of structures and shipboard outfitting. The tightness of all tanks and watertight boundaries of ships during new construction and those relevant to major conversions or major repairs (repairs affecting structural integrity) is to be confirmed by these test procedures prior to the delivery of the ship.

3.2 Application

3.2.1 All gravity tanks and other boundaries required to be watertight or weathertight are to be tested in accordance with this section and proven to be tight and structurally adequate as follows:

- Gravity tanks for their tightness and structural adequacy.
- Watertight boundaries other than tank boundaries for their watertightness, and
- Weathertight boundaries for their weathertightness.

Note : Gravity tank means a tank that is subject to vapour pressure not greater than 0.07 [MPa].

“Watertight” means having scantlings and arrangements capable of preventing the passage of water in any direction under the head of water likely to occur in intact and damaged conditions. In the damaged condition, the head of water to be considered in the worst situation at equilibrium, including intermediate stage of flooding.

“Weathertight” means that in any sea conditions, water will not penetrate into the ship. Weathertight Closing appliances for hatches, doorways and other access openings, ventilators, air-pipes etc are to be such as to prevent the passage of water into the ship in all sea conditions.

3.2.2 The testing of the cargo containment systems of liquefied gas carriers is to be in accordance with Pt.5, Ch.4, Sec.4.10 and Table 3.4.2.

3.2.3 The testing of structures not listed in Table 3.4.1 or 3.4.2 is to be specially considered.

3.3 Test Types and Definitions

3.3.1 The following two types of tests are specified in this requirement:

.1) Structural Test : A test to verify the structural adequacy of tank construction. This may be a hydrostatic test or, where the situation warrants, a hydropneumatic test.

.2) Leak Test : A test to verify the tightness of a boundary. Unless a specific test is indicated, this may be a hydrostatic / hydropneumatic test or an air test. A hose test may be considered an acceptable form of leak test for certain boundaries, as indicated by note 3 of Table 3.4.1.

3.3.2 The definition of each test type is as follows:

Hydrostatic Test: (Leak and Structural)	A test wherein a space is filled with a liquid to a specified head
Hydropneumatic Test: (Leak and Structural)	A test combining a hydrostatic test and an air test, wherein a space is partially filled with a liquid and pressurized with air.
Hose Test (Leak)	A test to verify the tightness of a joint by a jet of water with the joint visible from the opposite side.
Air Tests: (Leak)	A test to verify tightness by means of air pressure differential and leak indicating solution. It includes tank air test and joint air tests, such as compressed air fillet weld tests and vacuum box tests.
Compressed Air Fillet Weld Test: (Leak)	An air test of fillet welded tee joints wherein leak indicating solution is applied on fillet welds
Vacuum Box Test: (Leak)	A box over a joint with leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks
Ultrasonic Test: (Leak)	A test to verify the tightness of the sealing of closing devices such as hatch covers by means of ultrasonic design techniques.
Penetration Test: (Leak)	A test to verify that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment by means of low surface tension liquids (i.e. dye penetrant test).

3.4 Test procedures

3.4.1 General

Tests are to be carried out in the presence of a Surveyor at a stage sufficiently close to the completion of work with all hatches, doors, windows, etc., installed and all penetrations including pipe connections fitted and before any ceiling and cement work is applied over the joints. Specific test requirements are given in 3.4.4 and Table 3.4.1. For the timing of the application of coating and the provision of safe access to joints, see 3.4.5, 3.4.6 and Table 3.4.3.

3.4.2 Structural test procedures

3.4.2.1 Type and time of test

Where a structural test is specified in Table 3.4.1 or Table 3.4.2, a hydrostatic test in accordance with 3.4.4.1 will be acceptable. Where practical limitations, (strength of building berth, light density of liquid, etc.) prevent the performance of a hydrostatic test, a hydropneumatic test in accordance with 3.4.4.2 may be accepted instead

A hydrostatic test or hydropneumatic test for the confirmation of structural adequacy may be carried out while the vessel is afloat provided the results of a leak test are confirmed to be satisfactory before the vessel is afloat.

3.4.2.2 Testing Schedule for New Construction or Major Structural Conversion

(Note : Concurrence of the Flag Administration is to be obtained prior to allowing relaxation for structural tests for tanks of same structural configuration and for tanks in sister vessels).

3.4.2.2.1 The tank boundaries are to be tested from at least one side. The tanks for structural test are to be selected so that all representative structural members are tested for the expected tension and compression.

3.4.2.2.2 Structural tests are to be carried out for at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor localized differences determined to be acceptable by the attending Surveyor) on each vessel provided all other tanks are tested for leaks by an air test. The acceptance of leak testing using an air test instead of a structural test does not apply to cargo space boundaries adjacent to other compartments in tankers and combination carriers or to the boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships.

3.4.2.2.3 Additional tanks may require structural testing if found necessary after the structural testing of the first tank.

3.4.2.2.4 When the structural adequacy of the tanks of a vessel were verified by the structural testing required in Table 3.4.1, subsequent vessels in the series (i.e. sister ships built from the same plans at the same shipyard) may be exempted from structural testing of tanks, provided that:

.1 Water-tightness of boundaries of all tanks is verified by leak tests and thorough inspections are carried out.

.2 Structural testing is carried out for at least one tank of each type among all tanks of each sister vessel.

.3 Additional tanks may require structural testing if found necessary after the structural testing of the first tank or if deemed necessary by the attending Surveyor.

For cargo space boundaries adjacent to other compartments in tankers and combination carriers or boundaries of tanks for segregated cargos or pollutant cargoes in other types of ships, the provision of 3.4.2.2.2 are to be applied in lieu of 3.4.2.2.4.2

3.4.2.2.5 Sister ships built (i.e keel laid) two years or more after the delivery of the last ship of the series, may be tested in accordance with 3.4.2.2.4 provided that:

1. General workmanship has been maintained (i.e. there has been no discontinuity of shipbuilding or significant changes in the construction methodology or technology at the yard, shipyard personnel are appropriately qualified and demonstrate an adequate level of workmanship as determined by IRS) and:

.2 An enhanced NDT programme is implemented for the tanks not subject to structural tests.

3.4.2.2.6 For the watertight boundaries of spaces other than tanks structural testing may be exempted, provided that the water-tightness of boundaries of exempted spaces is verified by leak tests and inspections. Structural testing may not be exempt and the requirements for structural testing of tanks in 3.4.2.2.1 to 3.4.2.2.5 are to be applied, for ballast holds, chain lockers and a representative cargo hold if intended for in-port ballasting.

3.4.3 Leak test procedures

3.4.3.1 For the leak tests specified in Table 3.4.1, tank air tests, compressed air fillet weld tests, vacuum box tests in accordance with 3.4.4.4 through 3.4.4.6, or their combination, will be acceptable. Hydrostatic or hydropneumatic tests may also be accepted as leak tests provided that 3.4.5, 3.4.6 and 3.4.7 are complied with. Hose tests will also be acceptable for such locations as specified in Table 3.4.1 with Note 3, in accordance with 3.4.4.3.

3.4.3.2 Air tests of joints may be carried out in the block stage provided that all work on the block that may affect the tightness of a joint is completed before the test. See also 3.4.5.1 for the application of final coatings and 3.4.6 for the safe access to joints and the summary in Table 3.4.3.

3.4.4 Test Methods

3.4.4.1 Hydrostatic Test

3.4.4.1.1 Unless another liquid is approved, hydrostatic test are to consist of filling the space with fresh water or sea water, whichever is appropriate for testing, to the level specified in Table 3.4.1 or Table 3.4.2.

3.4.4.1.2 In cases where a tank for higher density cargoes is to be tested with fresh water or sea water, the testing pressure height is to be specially considered.

3.4.4.1.3 All external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, other related damage and leaks.

3.4.4.2 Hydropneumatic test

3.4.4.2.1 Hydropneumatic tests, where approved, are to be such that the test condition, in conjunction with the approved liquid level and supplemental air pressure, will simulate the actual loading as far as practicable. The requirements and recommendations for tank air tests in 3.4.4.4 will also apply to hydropneumatic tests.

3.4.4.2.2 All external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, other related damage and leaks.

3.4.4.3 Hose test

3.4.4.3.1 Hose tests are to be carried out with the pressure in the hose nozzle maintained at least at 0.2 [MPa] i.e. (2 bar) during the test. The nozzle is to have a minimum inside diameter of 12 [mm] and be at a perpendicular distance from the joint not exceeding 1.5 [m]. The water jet is to impinge directly upon the weld.

3.4.4.3.2 Where a hose test is not practical because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where necessary by means such as a dye penetrant test or ultrasonic leak test or the equivalent.

3.4.4.4 Tank air test

3.4.4.4.1 All boundary welds, erection joints and penetrations, including pipe connections, are to be examined in accordance with approved procedure and under a stabilized pressure differential above atmospheric pressure not less than 0.015 [MPa], with a leak indicating solution such as soapy water/detergent or a proprietary brand applied.

3.4.4.4.2 A U-tube with a height sufficient to hold a head of water corresponding to the required test pressure is to be arranged. The cross sectional area of the U-tube is not to be less than that of the pipe supplying air to the tank. Instead of using a U-tube, two calibrated pressure gauges may be acceptable to verify required test pressure.

3.4.4.4.3 A double inspection is to be made of tested welds. The first is to be immediately upon applying the leak indication solution; the second is to be after approximately four or five minutes in order to detect those smaller leaks which may take time to appear.

3.4.4.5 Compressed air fillet weld test

3.4.4.5.1 In this air test, compressed air is injected from one end of a fillet welded joint and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges are to be arranged so that an air pressure of at least 0.015 [MPa] can be verified at each end of all passages within the portion being tested.

Note : Where a leak test is required for fabrication involving partial penetration welds, a compressed air test is also to be applied in the same manner as to fillet weld where the root face is large, i.e., 6-8 [mm].

3.4.4.6 Vacuum box test

3.4.4.6.1 A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak indicating solution applied to the weld cap vicinity. The air within the box is removed by an ejector to create a vacuum of 0.02 - 0.026 [MPa] inside the box.

3.4.4.7 Ultrasonic test

3.4.4.7.1 An ultrasonic echo transmitter is to be arranged inside of a compartment and a receiver is to be arranged on the outside. The watertight/weathertight boundaries of the compartment are scanned with the receiver in order to detect an ultrasonic leak indication. A location where sound is detectable by the receiver indicates a leakage in the sealing of the compartment.

3.4.4.8 Dye penetration test

3.4.4.8.1 A test of butt welds or other weld joints uses the application of a low surface tension liquid at one side of a compartment boundary or structural arrangement. If no liquid is detected on the opposite sides of the boundaries after the expiration of a defined period of time, this indicates tightness of the boundaries. In certain cases, a developer solution may be painted or sprayed on the other side of the weld to aid leak detection.

3.4.4.9 Other tests

3.4.4.9.1 Other methods of testing may be considered by IRS upon submission of full particulars prior to the commencement of testing.

3.4.5 Application of coating

3.4.5.1 Final coating

3.4.5.1.1 For butt joints welded by an automatic process, the final coating may be applied any time before the completion of a leak test of spaces bounded by the joints, provided that the welds have been carefully inspected visually to the satisfaction of the Surveyor.

3.4.5.1.2 However, the Surveyor reserves the right to require a leak test prior to the application of the final coating over automatic erection butt welds.

3.4.5.1.3 For all other joints, the final coating is to be applied after the completion of the leak test of the joint. See also Table 3.4.3.

3.4.5.2 Temporary coating

3.4.5.2.1 Any temporary coating which may conceal defects or leaks is to be applied at the time as specified for the final coating (See 3.4.5.1). This requirement does not apply to shop primer.

3.4.6 Safe access to joints

3.4.6.1 For leak tests, a safe access to all joints under examination is to be provided. See also Table 3.4.3.

3.4.7 Hydrostatic or hydropneumatic tightness test

3.4.7.1 In cases where the hydrostatic or hydropneumatic tests are applied instead of a specific leak test, examined boundaries must be dew-free, otherwise small leaks are not visible.

Table 3.4.1 : Test requirements for Tanks and Boundaries

Sr. No.	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
1	Double bottom tanks[4]	Leak and structural[1]	The greater of - top of the overflow - to 2.4 [m] above top of tank[2], or - to bulkhead deck	
2	Double bottom voids[5]	Leak	See 3.4.4.4 through 3.4.4.6, as applicable	Including pump room double bottom and bunker tank protection double hull required by MARPOL Annex I
3	Double side tanks	Leak and structural[1]	The greater of - top of the overflow, - to 2.4 [m] above top of tank[2,8], or - to bulkhead deck	
4	Double side voids	Leak	See 3.4.4.4 through 3.4.4.6, as applicable	
5	Deep tanks other than those listed elsewhere in this table	Leak and structural[1]	The greater of - top of the overflow, - to 2.4 [m] above top of tank[2,8]	
6	Cargo oil tanks	Leak and structural[1]	The greater of - top of the overflow, - to 2.4 [m] above top of tank[2,8], or - top of tank[2] plus setting of any pressure relief valve	
7	Ballast hold of bulk carriers	Leak and structural[1]	- Top of cargo hatch coaming	
8	Peak tanks	Leak and structual[1]	The greater of - top of the overflow, or - to 2.4 [m] above top of tank[2,8]	After peak to be tested after installation of stern tube
9	a. Fore peak spaces with equipment	Leak	See 3.4.4.3 through 3.4.4.6, as applicable	
	b. Fore peak voids	Leak and structural[1, 11]	To bulkhead deck	
	c. Aft peak spaces with equipment	Leak	See 3.4.4.3 through 3.4.4.6, as applicable	
	d. Aft peak voids	Leak	See 3.4.4.4 through 3.4.4.6, as applicable	After peak to be tested after installation of stern tube
10	Cofferdams	Leak	See 3.4.4.4 through 3.4.4.6, as applicable	
11	a. Watertight bulkheads	Leak[10]	See 3.4.4.3 through 3.4.4.6, as applicable[7]	
	b. Superstructure end bulkheads	Leak	See 3.4.4.3 through 3.4.4.6, as applicable	

Table 3.4.1 : (Contd.)

Sr. No.	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
12	Watertight doors below freeboard or bulkhead deck	Leak [6, 7]	See 3.4.4.3 through 3.4.4.6, as applicable	
13	Double plate rudder blades	Leak	See 3.4.4.4 through 3.4.4.6, as applicable	
14	Shaft tunnels clear of deep tanks	Leak[3]	See 3.4.4.3 through 3.4.4.6, as applicable	
15	Shell doors	Leak[3, 9]	See 3.4.4.3 through 3.4.4.6, as applicable	
16	Weathertight hatch covers and closing appliances	Leak[3,7]	See 3.4.4.3 through 3.4.4.6, as applicable	Hatch covers closed by tarpaulins and battens excluded
17	Dual purpose tanks / dry cargo hatch covers	Leak[3,7]	See 3.4.4.3 through 3.4.4.6, as applicable	In addition to structural test in item 6 or 7
18	Chain lockers	Leak and structural[1]	Top of chain pipe	
19	L.O. sump tanks and other similar tanks/spaces under main engines	Leak	- See 3.4.4.3 through 3.4.4.6 as applicable	
20	Ballast ducts	Leak and structural[1]	The greater of - Ballast pump maximum pressure, or - Setting of any pressure relief valve	
21	Fuel Oil Tanks	Leak and structural[1]	The greater of - Top of the overflow, - To 2.4 [m] above top of tank[2] or - To top of tank[2] plus setting of any pressure relief valves, or - To bulkhead deck	

Notes :

1. Refer to section 3.4.2.2
2. The top of a tank is the deck forming the top of the tank excluding any hatchways.
3. Hose Test may also be considered as a method of the test, see 3.3.2.
4. Including tanks arranged in accordance with the provisions of SOLAS regulation II-1/9.4.
5. Including duct keels and dry compartments arranged in accordance with the provisions of SOLAS regulation II-1/11.2 and II-1/9.4 respectively, and/or oil fuel tank protection and pump room bottom protection arranged in accordance with the provisions of MARPOL Annex I, Chapter 3, Part A regulation 12A and Chapter 4, Part A, regulation 22 respectively.
6. Where water tightness of a watertight door has not been confirmed by prototype test, testing by filling watertight spaces with water is to be carried out. See SOLAS regulation II-1/16.2 and MSC/Circ.1176.
7. An alternative to the hose testing, other testing methods listed in 3.4.4.7 through 3.4.4.9 may be applicable subject to adequacy of such testing methods being verified. See SOLAS regulation II-1/11.1. For watertight bulkheads (item 11 a) alternatives to the hose testing may only be used where a hose test is not practicable.
8. For vessels of $L < 90$ [m], the head of water above highest point of tank may be $(0.02L + 0.6)$ [m], but not less than 1.0 [m]. However, in mechanically propelled cargo ships of 500 GT and above and passenger ships, for tanks forming part of the watertight subdivision (See Pt.3, Ch.10, 4.2.1), head of water above the highest point of tank is to be 2.4 [m].
9. Watertight shell doors are to be prototype tested prior to installation on board.
10. A “Leak and Structural test” (see 3.4.2.2) is to be carried out for a representative cargo hold if intended for in-port ballasting. The filling level requirement for testing cargo holds intended for in-port ballasting is to be the maximum loading that will occur in-port as indicated in the loading manual.
11. Structural test may be waived where demonstrated to be impracticable to the satisfaction of the attending Surveyor.

Table 3.4.2 : Additional Test requirements for Special Service Ships / Tanks

Sr. No.	Type of Ship / Tank	Structures to be tested	Type of Test	Test Head of Pressure	Remarks
1	Liquefied gas carriers	Integral tanks	Leak and structural	Refer Pt 5, Ch 4, 4.10	
		Hull structure supporting membrane or semi-membrane tanks		Refer Pt 5, Ch 4, 4.10	
		Independent tanks type A		Refer Pt 5, Ch 4, 4.10	
		Independent tanks type B		Refer Pt 5, Ch 4, 4.10	
		Independent tanks type C		Refer Pt 5, Ch 4, 4.10	
2	Edible liquid tanks	Independent tanks	Leak and structural	The greater of - top of the overflow, or - to 0.9 [m] above top of tank[1]	
3	Chemical carriers	Integral or independent cargo tanks	Leak and structural	The greater of - to 2.4 [m] above top of tank[1], or - to top of tank[1] plus setting of any pressure relief valve	Where a cargo tank is designed for the carriage of cargoes with specific gravities larger than 1 , an appropriate additional head is to be considered

Note : 1. Top of tank is deck forming the top of the tank excluding any hatchways

Table 3.4.3 : Application of leak test, coating and provision of safe access for type of welded joints

Type of welded joints		Leak Test	Coating[1]		Safe Access[2]	
			Before leak test	After leak test but before structural test	Leak test	Structural test
Butt	Automatic	Not required	Allowed[3]	N/A	Not required	Not required
	Manual or semi-automatic[4]	Required	Not allowed	Allowed	Required	Not required
Fillet	Boundary including penetrations	Required	Not allowed	Allowed	Required	Not required

Notes :

1. Coating refers to internal (tank / hold coating), where applied and external (shell/deck) painting. It does not refer to shop primer.

2. Temporary means of access for verification of the leak test.

3. The condition applies provided that the welds have been carefully inspected visually to the satisfaction of the Surveyor

4. Flux Core Arc Welding (FCAW) semiautomatic butt welds need not be tested provided that careful visual inspection show continuous uniform weld profile shape, free from repairs, and the results of NDE testing show no significant defects.

End of Chapter

Rules and Regulations
for the
Construction and Classification
of Steel Ships

Part 4

Main and Auxiliary Machinery

July 2016

IRCLASS
Indian Register of Shipping

Indian Register of Shipping

Part 4

Main and Auxiliary Machinery

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Chapter 1

General Requirements for the Design and Construction of Machinery

Contents

Section 1

General

1.1 Scope

1.1.1 The Chapters of this Part cover the construction and installation of main propulsion and auxiliary machinery systems, together with their associated equipment, boilers, pressure vessels and pumping and piping arrangements fitted in vessels classed or intended to be classed with IRS.

1.2 Machinery to be constructed under survey

1.2.1 In ships intended to be built under Special Survey, all important units of equipment are to be surveyed at the manufacturer's works. The workmanship is to be to the Surveyor's satisfaction and the Surveyor is to be satisfied that the components are suitable for the intended purpose and duty. Examples of such units are :

- Main propulsion engines, including their associated gearing, flexible couplings, scavenge blowers and superchargers;

- Boilers supplying steam for propulsion or for services essential for the safety or the operation of the ship at sea, including superheaters, economisers, desuper-heaters, steam receivers. All other boilers having working pressures exceeding 0.34 [N/mm^2], and having heating surfaces greater than 4.65 [m^2];

- Auxiliary engines which are the source of power for services essential for safety or for the operation of the ship at sea;

- Steering machinery;

- Athwartship thrust units, their prime movers and control mechanisms;

- All pumps necessary for the operation of vessel, main propulsion and essential machinery, e.g. boiler feed, cooling water circulating, condensate extraction, oil fuel, lubricating oil, etc.;

- All heat exchangers necessary for the operation of main propulsion and essential machinery, e.g. air, water and lubricating oil coolers, oil fuel and water heaters, de-aerators and condensers, evaporators and distiller units;

- Air compressors, air receivers and other pressure vessels necessary for the operation of main propulsion and essential machinery. Any other unfired pressure vessels for which plans are required to be submitted for approval in accordance with the requirements of Ch.5;

- Alarm and control equipment as detailed in Ch.7;

- Electrical equipment and electrical propelling machinery as detailed in Ch.8.

- All pumps essential for safety of the ship, e.g. fire, bilge and ballast pumps; and

- Valves and other components detailed in Ch.2.

1.3 Extent of survey

1.3.1 The Surveyors are to examine and test the materials and workmanship from the commencement of work until the final test of the machinery under full power working conditions. Any defects, etc., are to be indicated as early as possible.

1.3.2 Where items of machinery are manufactured as individual or series produced units, IRS would be prepared to give consideration to the adoption of a survey procedure based upon quality assurance concepts as detailed in Sec.4.

1.4 Departures from the rules

1.4.1 Where it is proposed to depart from the requirements of the Rules, IRS will be prepared to give due consideration to the circumstances of any special case.

1.4.2 Any novelty in the construction of the machinery, boilers or pressure vessels is to be reported to IRS.

1.5 Plans and particulars

1.5.1 Before the work is commenced, plans in triplicate of all machinery items, as detailed in relevant Chapters of this Part giving the requirements for individual systems, are to be submitted for approval. The particulars of the machinery, including power ratings and design calculations, where applicable, necessary to verify the design, are also to be submitted. Any subsequent modifications are subject to approval before being put in to operation.

1.5.2 The strength requirements for rotating parts of the machinery, as specified in relevant Chapters of this Part, are based upon strength consideration only and their application does not relieve the manufacturer from the responsibility for the presence of dangerous vibrations in the installation at speeds within the operating range.

1.6 Availability of machinery for operation

1.6.1 Ship's machinery is to be so arranged that it can be brought in to operation from the "dead ship" condition using only the facilities available on board. "Dead ship" condition is understood to mean a condition under which the main propulsion plant, boilers and auxiliaries are not in operation and in restoring the propulsion, no stored energy for starting and operating the propulsion plant, the main source of electrical power and other essential auxiliaries is assumed to be available. In order to restore operation from the "dead ship" condition, an emergency generator complying with the requirements of Pt.4, Ch.8, Cl.2.8 may be used provided that the emergency power supply from it is available at all times. It is assumed that means are available to start the emergency generator at all times.

1.6.2 "Blackout" is a sudden loss of electric power in the main distribution system. All means of starting by stored energy are available.

1.7 Environmental conditions

1.7.1 All components and systems covered by the Rules are to be designed to operate under the following environmental conditions if not otherwise specified in the detailed requirements for the component or system:

- ambient air temperature in the machinery space between 0°C and 55°C;

- relative humidity of air in the machinery space up to 96 per cent;

- sea water temperature up to 32°C; and

- list, rolling, trim and pitch in accordance with Table 1.7.1.

1.7.2 Where the Rules have requirements for capacity or effect of machinery, these are to be based on a total barometric pressure of 1 bar, an engine room ambient temperature or suction air temperature of 45°C, a relative humidity of 60 per cent and a sea water temperature or where applicable the temperature of the charge air coolant at inlet of 32°C. The engine manufacturer is not expected to provide simulated ambient reference conditions at test bed.

1.7.3 In the case of ships to be classed for restricted service, the rating is to be suitable for the temperature conditions associated with the geographical limits of the restricted service.

1.7.4 Where electrical equipment is installed within environmentally controlled spaces the ambient temperature for which the equipment is suitable may be reduced from 45°C to a value not less than 35°C provided:

- The equipment is not for use for emergency services.

Table 1.7.1 : Machinery inclinations

Installations/Components	**Angle of inclination [1]**			
	Athwartships		**Fore and aft**	
	Static	**Dynamic**	**Static**	**Dynamic**
Main and auxiliary machinery	15°	22.5°	5°[4]	7.5°
Safety equipment e.g. emergency power installations, emergency fire pumps and their devices Switch gear, electric and electronic appliances[2] and remote control systems	22.5°[3]	22.5°[3]	10°	10°

Notes

1 Athwartships and fore and aft inclinations occur simultaneously.

2 Switches and controls are to remain in their last set position. Upto an angle of inclination of 45° no undesired switching operations or operational changes may occur.

3 In ships for the carriage of liquefied gases and of chemicals the emergency power supply must also remain operable with the ship flooded to a final athwartships inclination upto maximum of 30°.

4 For ships where Rule length (L) exceeds 100 [m], the fore and aft static angle of inclination can be taken as 500/L degrees.

5 Any deviations from these angles of inclination taking into consideration the size and service conditions of the ship will be specially considered.

- Temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is capable of satisfactorily maintaining the design temperature.

- The equipment is able to be initially set to work safely within a 45°C ambient temperature until such a time that the lesser ambient temperature may be achieved. The cooling equipment is to be rated for a 45°C ambient temperature.

- Audible and visual alarms are provided, at a continually manned control station, to indicate any malfunction of the cooling units.

- It is to be ensured that electrical cables for their entire length are adequately rated for the maximum ambient temperature to which they are exposed along their length.

- The equipment used for cooling and maintaining the lesser ambient temperature is to be classified as a secondary essential service, as defined in Ch.8, sec.1.

1.8 Power ratings

1.8.1 In the following Chapters, where the dimensions of any particular component are determined from shaft power, P in kW, and revolutions per minute, R, the values to be used are to be derived from the following:

- For main propulsion machinery, the maximum shaft power and corresponding revolutions per minute giving the maximum torque for which the machinery is to be classed; and

- For auxiliary machinery, the maximum continuous shaft power and corresponding revolutions per minute which will be used in service.

1.9 Units

1.9.1 Units and formulae included in the Rules are shown in SI units.

1.9.2 Where the metric version of shaft power, i.e. (shp), appears in the Rules, 1 shp is equivalent to 75 [kgf] [m/sec] or 0.735 [kW].

1.9.3 Pressure gauges may be calibrated in bar

where,

1 bar = 0.1 [N/mm^2] = 1.02 [kgf/cm^2].

1.10 Astern power

1.10.1 In order to maintain sufficient maneuverability and secure control of the ship in all normal conditions, the main propulsion machinery is to be capable of reversing the direction of thrust so as to bring the ship to rest from the maximum service speed. The main propulsion machinery is to be capable of maintaining in free route astern at least 70% of the ahead revolutions.

1.10.2 Where steam turbines are used for main propulsion, they are to be capable of maintaining in free route astern at least 70% of the ahead revolutions for a period of at least 15 minutes. The astern trial is to be limited to 30 minutes or in accordance with manufacturer's recommendation to avoid overheating of the turbine due to the effects of "windage" and friction.

1.10.3 For main propulsion systems with reversing gears, controllable pitch propeller or electric propeller drive, running astern is not to lead to overload of the propulsion machinery.

1.10.4 The ahead revolutions as mentioned above are understood as those corresponding to the maximum continuous ahead power for which the vessel is classed.

1.10.5 The reversing characteristics of the propulsion plant are to be demonstrated and recorded during trials.

1.11 Fuel

1.11.1 The flash point (closed cup test) of oil fuel for use in ships classed for unrestricted service, in general, is not to be less than 60°C.

1.11.2 For emergency generator engines, fuel having a flash point (closed cup test) of not less than 43°C may be used.

1.11.3 Fuels with flash points lower than 60°C, but not less than 43°C unless specially approved, may be used in ships intended for service restricted to geographical limits where it can be ensured that the temperature of the machinery and boiler spaces will always be 10°C below the flash point of fuel. In such cases, safety precautions and the arrangements for storage and pumping will be specially considered. (Also refer Pt.6, Ch.2, 1.2.1).

1.11.4 The use of fuels having a lower flash point than specified in 1.11.1 to 1.11.3 as applicable may be permitted provided that such fuel is not stored in any machinery space and arrangements for the complete installation are specially approved.

1.11.5 For engines operating on "boil-off" vapours from the cargo, the arrangements will be specially considered.

1.12 Materials

1.12.1 The materials used in the construction are to be manufactured and tested in accordance with the requirements of Pt.2 of the Rules. Materials for which provision is not made therein may be accepted, provided that they comply with an approved specification and such tests as may be considered necessary.

1.12.2 Installation of material which contain asbestos is prohibited.

1.13 Alternative design and arrangements

1.13.1 The Rules generally cover the requirements of SOLAS Ch.II-1, Parts C, D and E. Design and arrangements alternative to these requirements may be accepted based on SOLAS Reg. II-1/55 and MSC.1/Circ. 1212.

Section 2

Machinery Room Arrangements

2.1 General

2.1.1 The machinery is to be so designed, installed and protected that risks of fire, explosions, accidental pollution, leakages and accidents thereof, and accidents to personnel working in machinery spaces will be minimised.

2.1.2 The design and arrangement of machinery foundations, shaft connections, piping and ducting is to take into account the effects of thermal expansion, vibrations, mis-alignment and hull interaction to ensure operation within safe limits.

Bolts and nuts exposed to dynamic forces and vibrations are to be properly secured.

2.2 Accessibility

2.2.1 Accessibility, for attendance and maintenance purposes, is to be provided for machinery plants.

2.3 Fire protection

2.3.1 All surfaces of machinery where the surface temperature may exceed 220°C, e.g., steam and exhaust gas lines, silencers, boilers, exhaust gas boilers, turbo blowers, etc. are to be effectively shielded to prevent ignition of combustible materials coming in to contact with them. Where insulation covering these surfaces is oil absorbing or may permit penetration of oil, the insulation is to be encased in steel or its equivalent.

2.3.2 The insulation is to be of a type and so supported that it will not crack or deteriorate when subjected to vibration.

2.3.3 Oil spillages coming into contact with hot surfaces, electrical installations or other sources of ignition.

a) Precautions (e.g. shielding) are to be taken to prevent oil that may escape under pressure from any pump, filter or heater or piping from coming into contact with sources of ignition.

b) Oil tanks, pipes, filters, heaters, etc. are not to be located immediately above or near units of high temperature including boilers, steam pipe lines, exhaust manifolds, silencers or other equipment required to be insulated and electrical equipment, as far as practicable. In particular, oil fuel filters under pressure for diesel engines are to be located such that in the event of leakage, oil cannot be sprayed on to the exhaust manifold.

c) Oil filters fitted in parallel for the purpose of enabling cleaning without disturbing oil supply to engines (e.g. duplex filters) are to be provided with arrangements that will minimise the possibility of a filter under pressure being opened by mistake. Filter/filter chambers are to be provided with suitable means for :

- venting when put in to operation; and

- depressurizing before being opened.

Valves or cocks with drain pipes led to a safe location are to be used for this purpose.

d) Hydraulic units with working pressure above 15 bar are preferably to be placed in separate spaces. If it is impracticable to locate such units in separate space, adequate shielding is to be provided.

2.3.4 Flammable or oil absorbing materials are not to be used in floors, gratings, etc. in boiler and engine rooms, shaft tunnels or in compartments where settling tanks are installed.

2.3.5 Segregation of oil fuel purifiers

a) Oil fuel purifiers for heated oil are to be in separate room enclosed by steel bulkheads extending from deck to deck and provided with self-closing steel doors.

b) The room is to be provided with :

- independent mechanical ventilation or a ventilation arrangement which can be isolated from the machinery space ventilation;

- fire detecting system; and

- fixed fire extinguishing installation.

The extinguishing installation is to be capable of being activated from outside the room. Closing of ventilation openings is to be effected from a position close to where the extinguishing system is activated. The extinguishing system is to be separate for the room, but may be part of the main fire extinguishing system for the machinery spaces.

c) If it is impracticable to locate the oil fuel purifiers in a separate space, IRS will give special consideration with regard to location, containment of possible leakages, shielding and ventilation. A local fixed fire extinguishing system is to be provided which is to be capable of being activated manually from the machinery control position or from other suitable location. If automatic release is provided, additional manual release is to be arranged.

2.4 Ventilation

2.4.1 All spaces, including engine and cargo pump spaces, where flammable or toxic gases or vapours may accumulate, are to be provided with adequate ventilation under all conditions.

2.4.2 Machinery spaces of Category A are be adequately ventilated so that a sufficient supply of air is maintained to the spaces for the safety and comfort of personnel and for operation of the machinery, when machinery or boilers are operating at full power in all weather conditions including heavy weather. Any other machinery space is to be adequately ventilated appropriate for the purpose of that machinery space.

IR2.4.2 The openings on deck through which the air is supplied to machinery space should be suitably protected (taking into account the requirements of Pt.3, Ch.13, Sec.2.2 and Sec.2.3).

The machinery spaces of Category A and other machinery spaces are as defined in Pt.6, Ch.1, Clauses 3.31 and 3.30 respectively.

2.5 Communications

2.5.1 At least two independent means of communication are to be provided between the bridge and engine room control station from which the engines are normally controlled.

One of these means is to visually indicate the order and response, both at the engine room control station and on the bridge.

2.5.2 At least one means of communication is to be provided between the bridge and any other control position(s) from which the propulsion machinery may be controlled.

2.5.3 Propulsion machinery orders from the navigation bridge are to be indicated in the main machinery control room and at the manoeuvring platform.

2.6 Machinery controls

2.6.1 Main and auxiliary machinery essential for the propulsion, control and safety of ship are to be provided with effective means for its operation and control. All control systems essential for the propulsion, control and safety of the ship are to be independent or designed such that failure of one system will not affect the performance of the other system.

2.6.2 Where remote control of propulsion machinery from the navigating bridge is provided, the control is to be performed by a single control device for each independent propeller, with automatic control of all associated services, including, where necessary, means of preventing overload of the propulsion machinery.

Section 3

Trials

3.1 General

3.1.1 Tests of components and trials of machinery, as detailed in the Chapters giving the requirements for individual systems are to be carried out to the satisfaction of the Surveyors.

3.2 Sea trials

3.2.1 For all types of installations, the sea trials are to be of sufficient duration, and carried out under normal maneuvering conditions, to prove the machinery under rated power. The trials are also to demonstrate that any vibration which may occur within the operating speed range is acceptable.

3.2.2 The trials are to include demonstrations of the following :

- The adequacy of the starting arrangements to provide the required number of starts of the main engines;

- The ability of the machinery to reverse the direction of thrust of the propeller/propulsion device in sufficient time, under normal maneuvering conditions, and so bring the ship to rest from maximum ahead rated speed; and

- In turbine installations, the ability to permit astern running at 70 per cent of the full power ahead revolutions without adverse effects. The astern trial need not be of more than 30 minutes duration.

3.2.3 Where controllable pitch propellers are fitted, the free route astern trial is to be carried out with the propeller blades set in full pitch astern position. Where emergency manual pitch setting facilities are provided, their operation is to be demonstrated to the satisfaction of the Surveyors.

3.2.4 In geared installations, prior to full power sea trials, the gear teeth are to be suitably coated to demonstrate the contact markings, and on conclusion of sea trials all gears are to be opened up sufficiently to permit the Surveyors to make an inspection of the teeth. The marking is to indicate freedom from hard bearing, particularly towards the end of the teeth, including both ends of each helix where applicable.

3.2.5 The stopping times, ship headings and distances recorded on trials, together with the results of trials to determine the ability of ships having multiple propellers or propulsion/steering arrangements to navigate and maneuver with one or more such devices inoperative, are to be available on board for the use of the master or designated personnel.

3.2.6 Where the ship is provided with supplementary means for maneuvering or stopping, the effectiveness of such means is to be demonstrated and recorded as referred to in 3.2.5.

3.2.7 All trials are to be to Surveyor's satisfaction.

Section 4

Certification of Machinery and Components Based on Alternative Certification Scheme

4.1 General

4.1.1 Machinery and components may be certified by Alternative Certification Scheme (ACS) for products including machinery and components as described in Part 1, Chapter 1, Section 4 of the Rules.

4.2 Certification of diesel engines

4.2.1 Certification of diesel engines based on Alternative Certification Scheme described in Part1, Chapter 1, Section 4 of the Rules can be considered only for diesel engines which have been type approved in accordance with IRS type approval scheme.

4.2.2 Certification of individual components of diesel engines is to be undertaken in accordance with the *Classification Note: "Approval of I.C Engines".*

End of Chapter

Chapter 2

Piping Design Requirements

Contents

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Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter apply to the design and construction of piping systems, including pipe fittings and valves forming parts of such systems for the following services:

Air, vapour, gas (excluding liquefied gas cargo and process piping), water, lubricating oil, fuel oil, hydraulic fluid systems for steering gear, toxic gas and liquids, cargo oil and tank cleaning piping and open ended lines such as drains, overflows, vents and boiler escape pipes.

1.1.2 The requirements of this Chapter do not cover the following:

Exhaust pipes from internal combustion engines and gas turbines, and pipes forming integral part of a boiler.

1.1.3 Hydraulic fluid systems other than those for steering gear will be specially considered.

1.1.4 For requirements pertaining to piping systems for liquefied gases (cargo and process) and cargo piping systems of ships carrying chemicals in bulk reference should be made to applicable Chapters of Pt.5 of the Rules.

1.2 Classes of pipes

1.2.1 For the purpose of testing, type of joints to be adopted, heat treatment and welding procedure, piping systems are divided into three classes, as given in Table 1.2.1.

1.3 Design pressure

1.3.1 The design pressure, P, is the maximum permissible working pressure and is to be not less than the highest set pressure of the safety valve or relief valve. For oil fuel pipes the design pressure is to be taken in accordance with Table 1.3.1. For gaseous fuel, the design pressure will be specially considered.

1.3.2 In water tube boiler installations, the design pressure for steam piping between the boiler and integral superheater outlet is to be taken as the design pressure of the boiler, i.e. not less than the highest set pressure of any safety valve on the boiler drum. For piping leading from the superheater outlet, the design pressure is to be taken as the highest set pressure of the superheater safety valves.

1.3.3 The design pressure of feed piping and other piping on the discharge from pumps is to be taken as the pump pressure at full rated speed against a shut valve. Where a safety valve or other protective device is fitted to restrict the pressure to a lower value than the shut valve load, the design pressure is to be the highest set pressure of the protective device.

Table 1.2.1 : Classes of piping systems [3,4]

Piping system	Class I	Class II	Class III
Toxic or corrosive media	Without special safeguards	Not to be used	Not to be used
a) Flammable media heated above flash point[2] b) Flammable media having flash point below 60°C[2] c) Liquefied gas	Without special safeguards	With special safeguards[1]	Not to be used
Steam	P > 16 or T > 300	16 ≥ P > 7 and 300 ≥ T > 170	P ≤ 7 and T ≤ 170
Thermal Oil	P > 16 or T > 300	16 ≥ P > 7 and 300 ≥ T > 150	P ≤ 7 and T ≤ 150
Fuel oil + Lubricating oil + Flammable hydraulic oil	P > 16 or T > 150	16 ≥ P > 7 and 150 ≥ T > 60	P ≤ 7 and T ≤ 60
Other media[5] including water, air, gases, non-flammable hydraulic oil	P > 40 or T > 300	40 ≥ P > 16 and 300 ≥ T > 200	P ≤ 16 and T ≤ 200

Notes:

1 Safeguards for reducing leakage possibility and limiting its consequences will be specially considered e.g. leading pipes in positions where leakage of internal fluids will not cause a potential hazard or damage to surrounding areas or by the usage of pipe ducts, shielding, screening etc.
2 Cargo oil pipes belong to Class III piping systems.
3 P = Design pressure in bar as defined in 1.3
4 T = Design temperature in °C as defined in 1.4.
5 For open ended pipes (drains, overflow, vents, exhaust gas lines, boiler escape lines, etc.) irrespective of the temperature, Class III pipes may be used.

Table 1.3.1 : Definition of the design pressure for fuel oil systems

Working temperature / Working Pressure (WP)	T ≤ 60°C	T > 60°C
WP ≤ **7 bar**	3 bar or max. working pressure, whichever is greater	3 bar or max. working pressure, whichever is greater
WP > 7 bar	Max. working pressure	14 bar or max. working pressure, whichever is greater

1.4 Design temperature

1.4.1 The design temperature is to be taken as the maximum temperature of the internal fluid, but in no case is it to be less than 50°C. For special cases the design temperature will be specially considered.

1.4.2 In the case of pipes for superheated steam, the temperature is to be taken as the designed operating steam temperature for the pipeline, provided that the temperature at the superheater outlet is closely controlled. Where temperature fluctuations exceeding 15°C above the designed temperature are to be expected in normal service, the steam temperature to be used for determining the allowable stress is to be increased by the amount of this excess.

1.5 Design symbols

1.5.1 The symbols used in this Chapter are defined as follows:

a = percentage negative manufacturing tolerance on thickness;

b = bending allowance [mm];

c = corrosion allowance [mm];

D = outside diameter of pipe [mm] (see 1.5.2);

d = inside diameter of pipe [mm] (see 1.5.3);

e = weld efficiency factor (see 1.5.4);

P = design pressure, in bar;

P_t = hydraulic test pressure, in bar;

R = radius of curvature of a pipe bend at the centreline of the pipe [mm];

T = design temperature, in °C;

t = the minimum thickness of a straight pipe [mm], including corrosion allowance and negative tolerance, where applicable;

t_b = the minimum thickness of a straight pipe to be used for a pipe bend [mm]; including bending allowance, corrosion allowance and negative tolerance, where applicable;

K = maximum permissible design stress [N/mm^2].

1.5.2 The outside diameter, D, is subject to manufacturing tolerance, but these are not to be used in the evaluation of formulae.

1.5.3 The inside diameter, d, is not to be confused with nominal size, which is an accepted designation associated with outside diameters of standard rolling sizes.

1.5.4 The weld efficiency factor, e, is to be taken as 1.0 for seamless and electric resistance and induction welded steel pipes delivered by manufacturers approved for making welded pipes which are considered to be equivalent to seamless pipes. Where other methods of pipe manufacture are proposed, the value of e will be specially considered.

1.6 Heat treatment

1.6.1 Method of heat treatment and means of temperature control and recording are to be to the satisfaction of Surveyors.

1.7 Minimum thickness of pipes and bends

1.7.1 The minimum thickness, t, of straight pipes is to be determined by the following formula when ratio of outside-diameter to inside-diameter does not exceed the value 1.7:-

$$t = \left(\frac{PD}{20Ke + P} + c\right)\frac{100}{100 - a}\ [mm]$$

where,

P, D, e and a are defined in 1.5.1.

The maximum permissible design stress, K, is to be taken as the lowest of the following values:-

$$K = \frac{E_t}{1.6} \text{ or } \frac{R_{20}}{2.7} \text{ or } \frac{S_R}{1.6} \text{ or } \sigma_{1/100,000}/1$$

where,

$\sigma_{1/100,000}/1$ = average stress [N/mm^2] to produce 1% creep in 100,000 hrs at the design temperature.

E_t = specified minimum lower yield or 0.2 per cent proof stress at the design temperature

R_{20} = specified minimum tensile strength at ambient temperature

S_R = average stress to produce rupture in 100,000 hours at the design temperature.

Value of K may be obtained from Sec.2, Table 2.1.1 and Table 2.1.2 for carbon and low alloy steel pipes and fittings or from Sec.3, Table 3.2.1 for copper and copper alloys pipes and fittings.

c is obtained from Sec.2, Table 2.2.1 for carbon and low alloy steel pipes and fittings or from Sec.3, Table 3.2.3 for copper and copper alloys pipes and fittings.

1.7.2 Where it is proposed to use, for high temperature service, alloy steels other than those detailed in Sec.2, particulars of the tube sizes, design conditions and appropriate national or proprietary material specifications are to be submitted for consideration.

1.7.3 The minimum thickness, t_b, of a straight steel pipe to be used for a pipe bend is to be determined by the following formula, except where it can be demonstrated that the use of a thickness less than t_b would not reduce the thickness below 't' at any point after bending:-

$$t_b = \left(\frac{PD}{20Ke + P} + b + c \right) \frac{100}{100 - a} \text{ [mm]}$$

where,

P, D, R, e, b and a are defined in 1.5.1;

K and c are defined in 1.7.1;

$$b = \frac{D}{2.5R} \left(\frac{PD}{20Ke + P} \right) \text{ [mm]}$$

In general, R, is to be not less than 3D.

1.7.4 Notwithstanding the requirements of 1.7.1 and 1.7.3, the minimum thickness of pipes is not to be less than that indicated in Sec.2 or 3, as applicable. For threaded pipes, where permitted, the minimum thickness is to be measured at the bottom of the thread.

1.8 Flanges

1.8.1 The dimensions of flanges and related bolts, gaskets are to be chosen in accordance with recognised national/international standards. For special applications, the dimensions of the flanges and related bolts, will be specially considered.

1.8.2 Gaskets are to be suitable for the medium being conveyed under design pressure and temperature conditions and their dimensions and configurations are to be in accordance with a recognized standard and for the intended service.

1.9 Materials

1.9.1 Materials for ferrous castings and forgings of Class I and Class II piping systems are to be produced at Works approved by IRS and are in general to be tested in accordance with the requirements of Pt.2 of the Rules.

1.9.2 The manufacturer's test certificate for materials of valves and fittings will be accepted in lieu of the IRS certificate provided the maximum conditions are less than given in Table 1.9.1.

1.9.3 Pipes and bodies of valves, intended to be fitted on ship's side and bottom or on collision bulkhead, are to comply with the requirements of Class II piping systems.

1.9.4 Materials for Class III piping systems may be manufactured and tested in accordance with the requirements of an acceptable national/ international standard.

1.9.5 Stainless steel grades 304, 304L, 316 and 316L are generally not considered suitable for use in seawater piping systems due to their limited corrosion resistance in contact with sea water.

Table 1.9.1 : Maximum conditions for valves and fittings for which manufacturer's test certificate is acceptable

Material	Working temp.°C	DN = Nominal Diameter [mm] P_w = Working Pressure in bar
Carbon and low alloy steel Spheroidal or nodular cast iron	< 300	DN < 50 or P_w x DN < 2500
Copper alloy	< 200	DN < 50 or P_w x DN < 1500

Section 2

Carbon and Low Alloy Steel Pipes and Fittings

2.1 Materials

2.1.1 Pipes having forge butt welded longitudinal seams are not to be used for oil fuel systems, for heating coils in oil tanks, or for pressures exceeding 4.0 bar.

2.1.2 Steel pipes, valves and fittings may be used within the temperature limits indicated in Table 2.1.1 and Table 2.1.2. Where rimming steel is used for pipes manufactured by electric resistance or induction welding processes, the design temperature is limited to 400°C.

2.2 Minimum thickness of steel pipes and bends

2.2.1 The minimum thickness of steel pipes and bends is to be higher of that calculated by Sec.1, Cl.1.7 and that indicated in Table 2.2.2, Table 2.2.3 or Table 2.2.4 as applicable.

2.2.2 The value of 'c' to be used in Sec.1, Cl.1.7 is to be in accordance with Table 2.2.1

Table 2.1.1 : Carbon and carbon-manganese steel pipes

Specified min. tensile strength [N/mm^2]	Maximum permissible stress [N/mm^2]												
	Maximum design temperature °C												
	50	100	150	200	250	300	350	400	410	420	430	440	450
320	107	105	99	92	78	62	57	55	55	54	54	54	49
360	120	117	110	103	91	76	69	68	68	68	64	56	49
410	136	131	124	117	106	93	86	84	79	71	64	56	49
460	151	146	139	132	122	111	101	99	98	85	73	62	53
490	160	156	148	141	131	121	111	109	98	85	73	62	53

Table 2.1.2 : Alloy steel pipes

Type of steel	Specified min. tensile strength [N/mm^2]	Minimum permissible stress [N/mm^2]									
		Maximum design temperature °C									
		50	**100**	**200**	**300**	**350**	**400**	**440**	**450**	**460**	**470**
1 Cr 1/2 Mo	440	159	150	137	114	106	102	101	101	100	99
2 1/4 Cr 1 Mo annealed	410	76	67	57	50	47	45	44	43	43	42
2 1/4 Cr 1 Mo normalised and tempered (Note 1)	490	167	163	153	144	140	136	130	128	127	116
2 1/4 Cr 1 Mo normalised and tempered (Note 2)	490	167	163	153	144	140	136	130	122	114	105
1/2 Cr 1/2 Mo 1/4 V	460	166	162	147	120	115	111	106	105	103	102
		Maximum design temperature °C									
		480	**490**	**500**	**510**	**520**	**530**	**540**	**550**	**560**	**570**
1 Cr 1/2 Mo	440	98	97	91	76	62	51	42	34	27	22
2 1/4 Cr 1 Mo annealed	410	42	42	41	41	41	40	40	40	37	32
2 1/4 Cr 1 Mo normalised and tempered (Note 1)	490	106	96	86	76	67	58	49	43	37	32
2 1/4 Cr 1 Mo normalised and tempered (Note 2)	490	96	88	79	72	64	56	49	43	37	32
1/2 Cr 1/2 Mo 1/4 V	460	101	99	97	94	82	72	62	53	45	37

Notes:

1 Maximum permissible stress values applicable when the tempering temperature does not exceed 750°C.

2 Maximum permissible stress values applicable when the tempering temperature exceeds 750°C.

Table 2.2.1 : Values of 'c' for steel pipes

Piping service	**c [mm] (See Notes 1,2, 3)**
Superheated steam systems	0.3
Saturated steam systems	0.8
Steam coil systems in cargo tanks	2.0
Feed water for boilers in open circuit systems	1.5
Feed water for boilers in closed circuit systems	0.5
Blow down (for boilers) systems	1.5
Compressed air systems	1.0
Hydraulic/lubricating oil systems	0.3
Fuel oil systems	1.0
Cargo oil systems	2.0
Refrigerating plants	0.3
Fresh water systems	0.8
Sea water systems, in general	3.0

Table 2.2.1 (Contd.)

Notes:

1 For pipes passing through tanks an additional corrosion allowance is to be considered according to the figures given in Table and depending upon the external medium in order to account for the external corrosion.
2 The corrosion allowance may be reduced where pipes and any integral pipe joints are protected against corrosion by means of coating, lining etc., however, the reduction is not to be more than 50 percent in any case.
3 In the case of use of special alloy steel with sufficient corrosion resistance, the corrosion allowance may be reduced to zero.

Table 2.2.2 : Minimum wall thickness for steel pipes [11] [All dimension in mm]

Nominal size	External diameter D	Pipes in general [3, 4, 6, 8, 9, 10]	Venting overflow and sounding pipes for structural tanks [1-4, 6, 8]	Bilge ballast and general sea water pipes [1, 3-8]	Bilge, air, overflow and sounding pipes passing through ballast and fuel tanks, ballast lines through fuel tanks and fuel lines through ballast tanks [1-8]
6	10.2	1.6			
	12	1.6			
8	13.5	1.8			
10	17.2	1.8			
	19.3	1.8			
	20	2			
15	21.3	2		3.2	
	25	2		3.2	
20	26.9	2		3.2	
25	33.7	2		3.2	
	38	2	4.5	3.6	6.3
32	42.4	2	4.5	3.6	6.3
	44.5	2	4.5	3.6	6.3
40	48.3	2.3	4.5	3.6	6.3
	51	2.3	4.5	4	6.3
50	60.3	2.3	4.5	4	6.3
	63.5	2.3	4.5	4	6.3
	70	2.6	4.5	4	6.3
65	76.1	2.6	4.5	4.5	6.3
	82.5	2.6	4.5	4.5	6.3
80	88.9	2.9	4.5	4.5	7.1
90	101.6	2.9	4.5	4.5	7.1
	108	2.9	4.5	4.5	7.1
100	114.3	3.2	4.5	4.5	8
	127	3.2	4.5	4.5	8
	133	3.6	4.5	4.5	8
125	139.7	3.6	4.5	4.5	8
	152.4	4	4.5	4.5	8.8
150	168.3	4	4.5	4.5	8.8
	177.8	4.5	5	5	8.8
175	193.7	4.5	5.4	5.4	8.8
200	219.1	4.5	5.9	5.9	8.8
225	244.5	5	6.3	6.3	8.8

Table 2.2.2 (Contd.)					
Nominal size	External diameter D	Pipes in general [3, 4, 6, 8, 9, 10]	Venting overflow and sounding pipes for structural tanks [1-4, 6, 8]	Bilge ballast and general sea water pipes [1, 3-8]	Bilge, air, overflow and sounding pipes passing through ballast and fuel tanks, ballast lines through fuel tanks and fuel lines through ballast tanks [1-8]
250	273	5	6.3	6.3	8.8
	298.5	5.6	6.3	6.3	8.8
300	323.9	5.6	6.3	6.3	8.8
350	355.6	5.6	6.3	6.3	8.8
	368	5.6	6.3	6.3	8.8
400	406.4	6.3	6.3	6.3	8.8
450	457.2	6.3	6.3	6.3	8.8

Notes:

1 IRS may accept reduction in thickness of pipes by an amount not exceeding 1 mm for pipes efficiently protected against corrosion.

2 For sounding pipes, except for those for cargo tanks with cargo having a flash point less than 60°C, the minimum wall thickness is to apply to the part outside the tank.

3 For threaded pipes, where permitted, the minimum wall thickness is to measured at the bottom of the thread.

4 The external diameters and thicknesses have been selected from ISO 4200 for welded and seamless steel pipes. For pipes covered by other standards, slightly less thicknesses may be accepted.

5 The minimum wall thickness for bilge lines and ballast lines through deep tanks will be specially considered. See Pt.5 for thickness of ballast lines passing through oil cargo tanks.

6 The minimum wall thickness for pipes larger than 450 [mm] nominal size is to be in accordance with a national or international standard and in any case not less than the minimum wall thickness indicated for 450 [mm] pipe size.

7 The minimum internal diameter for bilge, sounding, air and overflow pipes shall be 50 [mm], 32 [mm] and 50 [mm] respectively.

8 In general the minimum thickness given in this table is the nominal wall thickness and no allowance need be made for negative tolerance and reduction in thickness due to bending.

9 Minimum wall thickness of exhaust gas pipes will be specially considered.

10 Minimum wall thickness for cargo oil lines will be specially considered.

11 This table is not applicable to air pipes above weather deck, scuppers and discharges which are covered by loadline convention and also to pipes covered by Table 2.2.3.

Table 2.2.3 : Minimum wall thickness for steel pipes for CO_2 fire extinguishing		
External diameter D [mm]	From bottles to distribution station	From distribution station to nozzles
21.3 - 26.9	3.2	2.6
30 - 48.3	4	3.2
51 - 60.3	4.5	3.6
63.5 - 76.1	5	3.6
82.5 - 88.9	5.6	4
101.6	6.3	4
108 - 114.3	7.1	4.5
127	8	4.5
133 - 139.7	8	5
152.4 - 168.3	8.8	5.6

Table 2.2.3 (Contd.)

Notes:

1 Pipes are to be galvanised at least internally, except those fitted in the engine room where galvanising may be dispensed with.
2 For threaded pipes, where allowed, the minimum wall thickness is to be measured at the bottom of the thread.
3 The external diameters and thicknesses have been selected from ISO recommendations R 336 for smooth welded and seamless steel pipes. For pipes covered by other standards, slightly less thickness may be accepted.
4 For larger diameters, the minimum wall thickness will be specially considered.
5 In general, the minimum thickness is the nominal wall thickness and no allowance need be made for negative tolerance and reduction in wall thickness due to bending.

Table 2.2.4 : Minimum wall thickness for austenitic stainless steel pipes

External diameter D [mm]	Minimum wall thickness [mm]	External diameter D [mm]	Minimum wall thickness [mm]
10.2 to 17.2	1.0	219.1	2.6
21.3 to 48.3	1.6	273.0	2.9
60.3 to 88.9	2.0	323.9 to 406.4	3.6
114.3 to 168.3	2.3	Over 406.4	4.0
Note : Diameters and thicknesses according to national or international standard may be accepted.			

2.3 Types of connection

2.3.1 Pipe lengths may be joined by

- screwed-on or welded on bolted flanges
- Butt welds between pipes or between pipes and valve chests or other fittings
- Socket weld joints
- Threaded sleeve joints
- Mechanical joints.

and are to be to a recognized standard or of a design proven to be suitable for the intended purpose.

2.4 Flange connections

2.4.1 Flange attachments are to be in accordance with recognized national or international standards applicable to piping system keeping in view the boundary fluids, design pressure and temperature conditions, external or cyclic loading and location.

2.4.2 Flanges may be cut from plates or may be forged or cast. The material is to be suitable for the design temperature. Flanges may be attached to the branches by screwing and expanding or by welding. Alternative methods of flange attachment may be accepted provided details are submitted for consideration.

2.4.3 Examples of accepted flanged connections and their uses are given in Fig.2.4.1 and Table 2.4.1 respectively.

2.4.4 Where flanges are secured by screwing, as indicated in Fig.2.4.1, the pipe and flange are to be screwed with a vanishing thread and the diameter of the screwed position of pipe over the thread is not to be appreciably less than the outside diameters of the unscrewed pipe. After the flange has been screwed hard home, the pipe is to be expanded into the flange.

The vanishing thread on a pipe is to be not less than three pitches in length, and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

Table 2.4.1 : Type of flange connections

Class of piping	t°C	Steam	Lub. and fuel oil	Other media
		Typical flange application	Typical flange application	Typical flange application
I [1)]	> 400	A	A - B	A
	≤ 400	A - B[2]		A - B
II	> 250	A - B - C	A - B - C	A - B - C
	≤ 250	A - B - C - D - E		A - B - C - D - E
III		A - B - C - D - E	A - B -C - E	A - B - C - D - E

1 For Class I only one condition is sufficient.

2 Type B for outer diameter < 150 [mm] only.

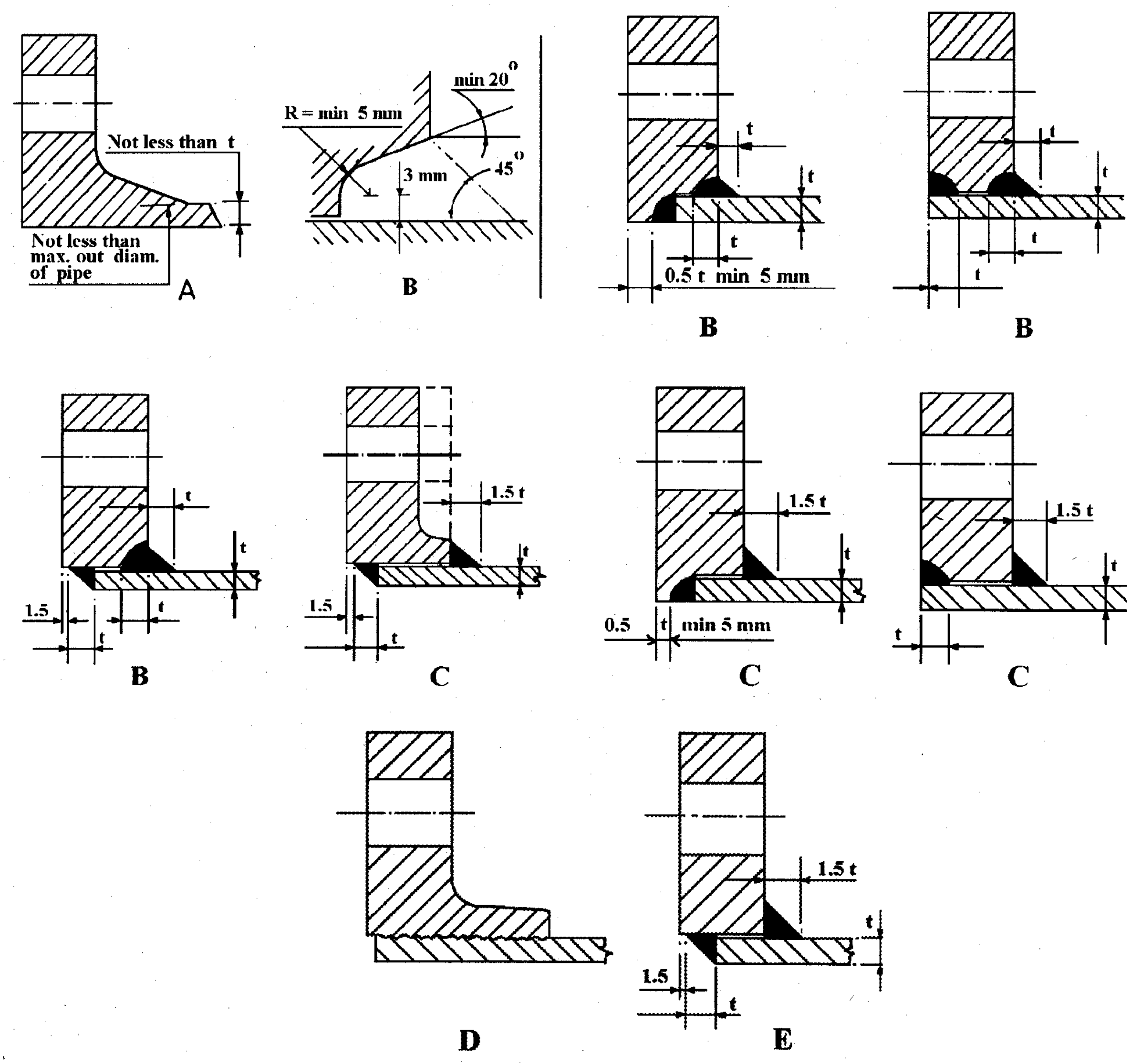


Fig. 2.4.1 : Types of flange connections

2.5 Threaded sleeve joints

2.5.1 Threaded sleeve joints requiring pressure-tight joints, having parallel or tapered threads in accordance with national or other established standards, may be used with carbon steel pipes within the limits given in Table 2.5.1 and for services other than pipe systems conveying combustible or toxic fluids or services where fatigue, severe erosion or crevice corrosion is expected to occur.

Threaded joints in CO_2 systems shall be allowed only inside protected spaces and in CO_2 cylinder rooms.

Threaded joints for direct connections of pipe lengths with tapered threads are to be allowed for

a) Class I piping having outside diameter not more than 33.7 [mm].

b) Class II and Class III piping having outside diameter not more than 60.3 [mm].

Threaded joints with parallel threads are to be allowed for Class III piping having outside diameter not more than 60.3 [mm].

In particular cases, sizes in excess of those mentioned above may be accepted by IRS if in compliance with a recognized national and/or international standard.

Table 2.5.1 : Limiting design conditions for threaded sleeve joints

Nominal bore [mm]	Maximum pressure in bar	Maximum temp.°C
≤ 25	12	260
> 25 ≤ 40	10	260
> 40 ≤ 80	8.5	260
> 80 ≤ 100	7	260

2.6 Welding, non-destructive examination and post-weld heat treatment of welded pipes

2.6.1 Requirements regarding welding procedures, non-destructive examination of welds and post-weld heat treatment are given in Ch.10.

2.7 Mechanical joints

2.7.1 Mechanical joints means devices intended for direct connection of pipe lengths other than by flanges, threaded joints or welding as described in 2.4, 2.5 and 2.6.

2.7.2 The requirements given here are applicable to pipe unions, compression couplings, slip-on joints as shown in Fig.2.7. Similar joints complying with these requirements may be acceptable.

2.7.3 Mechanical joints including pipe unions, compression couplings, slip-on joints and similar joints are to be of approved type for the pressure ratings, service conditions and the intended application. The construction and type are to conform to the examples shown in Fig.2.7 and are to be in accordance with Table 2.7.1 and Table 2.7.2 for their classification and application. (For approval refer "Type Approval of Mechanical Joints used in Piping").

2.7.4 Where the application of mechanical joints results in reduction in pipe wall thickness due to the use of bite type rings or other structural elements, this is to be taken into account in determining the minimum wall thickness of the pipe to withstand the design pressure.

The materials used in construction of mechanical joints is to be compatible with the piping material and internal and external media. In general the mechanical joints are to be of fire resistant type as required by Table 2.7.1.

2.7.5 The pressure pulsation, piping vibration, temperature variation and any other similar adverse effects occurring during operation on board is not to result in failure of joint integrity or its tightness.

2.7.6 Mechanical joints, which in the event of damage could cause fire or flooding, are not to be used in piping sections directly connected to the sea openings or tanks containing flammable fluids.

2.7.7 The mechanical joints are to be designed to withstand internal and external pressure as applicable and where used in suction lines are to be capable of operating under vacuum.

2.7.8 The number of mechanical joints in oil systems is to be kept to a minimum. In general, flanged joints conforming to recognised standards are to be used.

2.7.9 Piping in which a mechanical joint is fitted is to be adequately adjusted, aligned and supported Supports or hangers are not to be used to force alignment of piping at the point of connection.

2.7.10 Slip-on joints are normally not to be used in pipelines in cargo holds, tanks and other spaces which are not easily accessible, unless approved in each case.

2.7.11 Application of mechanical joints inside tanks may be permitted only for the same media that is in the tanks.

2.7.12 Unrestrained slip-on joints are to be used only in cases where compensation of lateral pipe deformation is necessary. Usage of these joints as the main means of pipe connection is not permitted.

2.7.13 In particular cases, sizes in excess of those mentioned in Table 2.7.2 may be accepted if in compliance with a recognised national and/or international standard.

2.7.14 Mechanical joints are to be subjected to the following tests:

.1 leakage test
.2 vacuum test
.3 vibration (fatigue) test
.4 fire endurance test
.5 burst pressure test at 4 times the design pressure (for design pressures above 200 bar, the burst pressure will be specially considered by IRS)
.6 pressure pulsation test
.7 assembly test
.8 pull out test.

NOTE : For details of tests refer classification notes, “Type Approval of Mechanical Joints used in Piping”.

2.7.15 The installation of mechanical joints is to be in accordance with the manufacturer’s assembly instructions and using special tools and gauges as required.

Table 2.7.1 : Application of mechanical joints

Systems		Kind of connections		
		Pipe unions	**Compression couplings 6)**	**Slip-on joints**
Flammable Fluids (Flash point ≤ 60°)				
1	Cargo oil lines	+	+	+5)
2	Crude oil washing lines	+	+	+5)
3	Vent lines	+	+	+3)
Inert Gas				
4	Water seal effluent lines	+	+	+
5	Scrubber effluent lines	+	+	+
6	Main lines	+	+	+2) 5)
7	Distributions lines	+	+	+5)
Flammable Fluids (Flash point > 60°)				
8	Cargo oil lines	+	+	+5)
9	Fuel oil lines	+	+	+3) 2)
10	Lubricating oil lines	+	+	+2) 3)
11	Hydraulic oil	+	+	+2) 3)
12	Thermal oil	+	+	+2) 3)
Sea Water				
13	Bilge lines	+	+	+1)
14	Fire main and water spray	+	+	+3)
15	Foam system	+	+	+3)
16	Sprinkler system	+	+	+3)
17	Ballast system	+	+	+1)
Sea Water (contd.)				
18	Cooling water system	+	+	+1)
19	Tank cleaning services	+	+	+
20	Non-essential systems	+	+	+
Fresh Water				
21	Cooling water system	+	+	+1)

Table 2.7.1 (Contd.)

Systems		Kind of connections		
		Pipe unions	**Compression couplings 6)**	**Slip-on joints**
Sounding / Vent				
Sanitary / Drains / Scuppers				
22	Condensate return	+	+	+1)
23	Non-essential system	+	+	+
24	Deck Drains (Internal)	+	+	+4)
25	Sanitary Drains	+	+	+
26	Scuppers and Discharge (Overboard)	+	+	-
27	Water tanks / Dry spaces	+	+	+
28	Oil tanks (f.p > 60°C)	+	+	+2) 3)
Miscellaneous				
29	Starting / Control air 1)	+	+	-
30	Service air (non-essential)	+	+	+
31	Brine	+	+	+
32	CO_2 system 1)	+	+	-
33	Steam	+	+	+ 7)

Abbreviations

+ Application is allowed
- Application is not allowed

Footnotes:

1) Inside machinery spaces of category A – only approved fire resistant types.
2) Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.
3) Approved fire resistant types
4) Above free board deck only.
5) In pump rooms and open decks – only approved fire resistant types.
6) If compression couplings include any components which readily deteriorate in case of fire, they are to be of approved fire resistant type as required for slip-on joints.
7) Slip type joints as shown in Fig.2.7 may be used for pipes on deck with a design pressure of 10 bar or less provided that they are restrained on the pipes (i.e. free axial moment of joint with respect to pipe is prevented).

Table 2.7.2 : Application of mechanical joints depending upon the class of piping

Types of joints	Classes of piping systems		
	Class I	**Class II**	**Class III**
Pipe Unions			
Welded and brazed type	+ (OD ≤ 60.3 mm)	+ (OD ≤ 60.3 mm)	+
Compression Couplings			
Swage type	+	+	+
Bite type Flared type	+ (OD ≤ 60.3 mm) + (OD ≤ 60.3 mm)	+ (OD ≤ 60.3 mm) + (OD ≤ 60.3 mm)	+ +
Press type	-	-	+

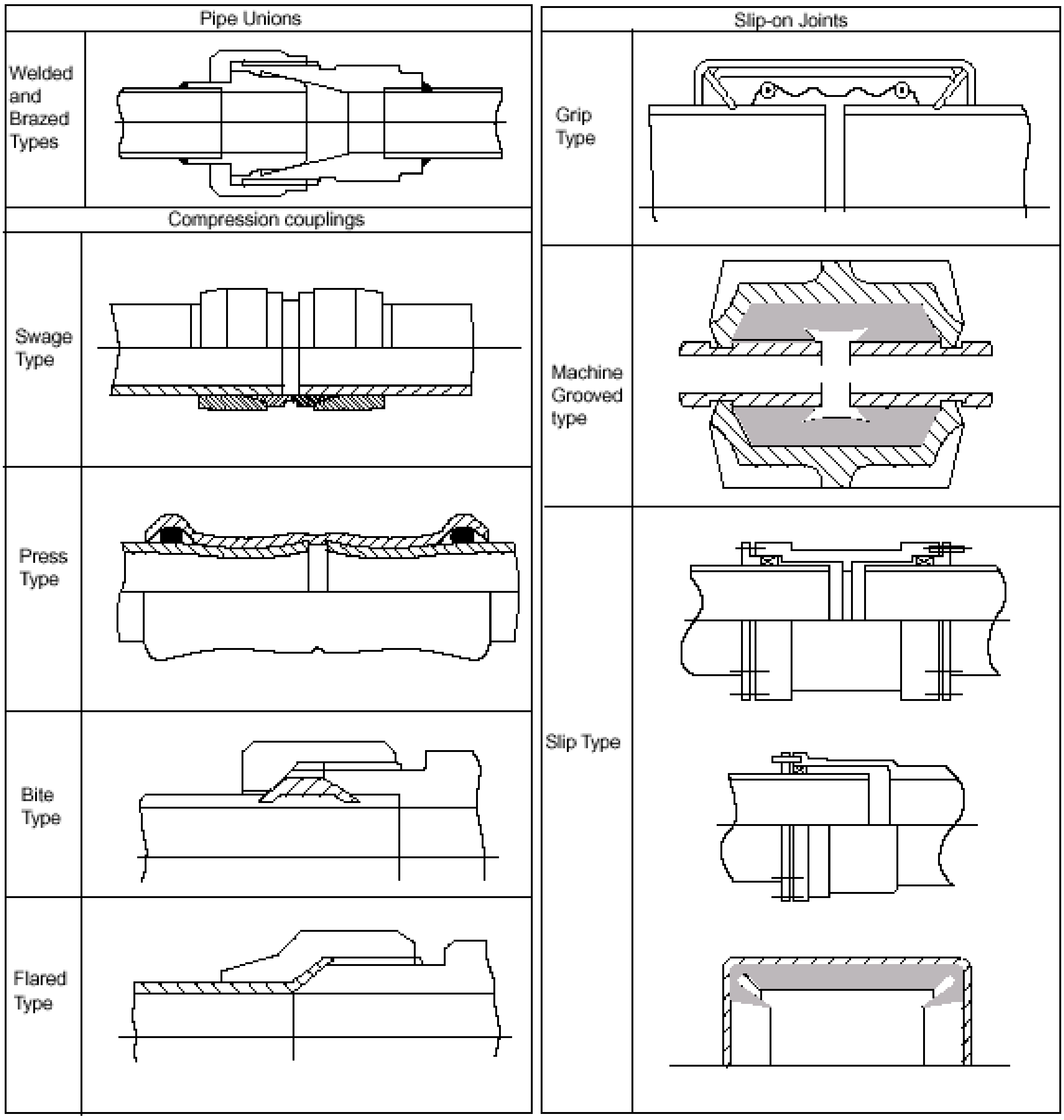
Table 2.7.2 : (Contd.)

Types of joints	**Classes of piping systems**		
	Class I	**Class II**	**Class III**
Slip-on joints			
Machine grooved type	+	+	+
Grip type	-	+	+
Slip type	-	+	+

Abbreviations:

+ Application is allowed
- Application is not allowed

Fig. 2.7 : Examples of mechanical joints



Section 3

Copper and Copper Alloy Pipes and Fittings

3.1 Materials

3.1.1 Pipes are to be seamless and branches are to be provided by cast or stamped fittings, pipe pressings or other approved fabrications. Copper pipes for class I and II are to be seamless.

3.1.2 Brazing and welding materials are to be suitable for the operating temperature and for the medium being carried. All brazing and welding are to be carried out to the satisfaction of the Surveyors.

3.1.3 In general, the maximum permissible service temperature of copper and copper alloy pipes, valves and fittings is not to exceed 200°C for copper and aluminium brass, and 300°C for copper nickel. Cast bronze valves and fittings complying with the requirements of Pt.2 Ch.8 may be accepted up to 260°C.

3.2 Minimum thickness of pipes

3.2.1 The minimum thickness of copper and copper alloy pipes and bends is to be higher of that calculated by Sec.1, Cl.1.7 and that indicated in Table 3.2.2.

3.2.2 The value of 'c' to be used in Sec.1, Cl.1.7 is to be in accordance with Table 3.2.3.

3.3 Heat treatment

3.3.1 Pipes which have been hardened by cold bending are to be suitably heat treated on completion of fabrication and prior to being tested by hydraulic pressure. Copper pipes are to be annealed and copper alloy pipes are to be either annealed or stress relief heat treated.

Table 3.2.1 : Copper and copper alloy pipes

Pipe material	Condition of supply	Specified min. tensile strength [N/mm^2]	Permissible stress [N/mm^2]					
			Maximum design temperature °C					
			50	75	100	125	150	175
Copper	Annealed	220	41.2	41.2	40.2	40.2	34.3	27.5
Aluminium brass	Annealed	320	78.5	78.5	78.5	78.5	78.5	78.5
95/5 90/10 copper nickel-iron	Annealed	270	68.6	68.6	67.7	65.7	63.7	61.8
70/30 copper nickel	Annealed	360	81.4	79.4	77.5	75.5	73.5	71.6
			Maximum design temperature °C					
			200	225	250	275	300	
Copper	Annealed	220	18.6	-	-	-	-	
Aluminium brass	Annealed	320	24.5	-	-	-	-	
95/5 90/10 copper nickel-iron	Annealed	270	58.8	55.9	52.0	48.1	44.1	
70/30 copper nickel	Annealed	360	69.6	67.7	65.7	63.7	61.8	

Notes :

1. Intermediate values may be determined by linear interpolation.
2. For materials not included in the Table, the permissible stress shall be specially considered by IRS.

Table 3.2.2 : Minimum thickness for copper and copper alloy pipes

Standard pipe sizes (outside diameter[mm])	Minimum overriding nominal thickness [mm]	
	Copper	Copper alloy
8 to 10	1.0	0.8
12 to 20	1.2	1.0
25 to 44.5	1.5	1.2
50 to 76.1	2.0	1.5
88.9 to 108	2.5	2.0
133 to 159	3.0	2.5
193.7 to 267	3.5	3.0
273 to 457.2	4.0	3.5
508	4.5	4.0

Table 3.2.3 : Corrosion allowance 'c' for copper and copper alloy pipes

Piping Material	c [mm]
Copper, brass and similar alloys, copper-tin alloys except those with lead contents	0.8
Copper-nickel alloys (with Ni ≥ 10%)	0.5
Note: For media without corrosive action in respect of the material employed and in case of special alloys with sufficient corrosion resistance, the corrosion allowance may be reduced to zero.	

Section 4

Cast Iron Pipes and Fittings

4.1 Spheroidal or nodular graphite cast iron

4.1.1 Spheroidal or nodular graphite iron castings for pipes, valves and fittings in Class II and III piping systems are to be made in a grade having a specified minimum elongation not less than 12 per cent on gauge length of $5.65\sqrt{S_o}$, where S_o is the actual cross-sectional area of the test piece.

4.1.2 Proposals for the use of this material in Class I piping systems will be specially considered, but in no case is the material to be used in systems where the design temperature exceeds 350°C.

4.1.3 Where the elongation is less than the minimum required by 4.1.1, the material is, in general, to be subject to the same limitations as grey cast iron.

4.2 Grey cast iron

4.2.1 Grey cast iron pipes, valves and fittings will, in general, be accepted in Class III piping systems except as stated in 4.2.2. Grey cast iron valves and fittings may be accepted in the Class II steam systems, but the design pressure or temperature is not to exceed 13 bar or 220°C respectively.

4.2.2 Grey cast iron is not to be used for the following:

a) Pipes for steam systems and fire extinguishing systems;

b) Pipes, valves and fittings for boiler blow down systems and other piping systems subject to shock or vibration;

c) Ship-side valves and fittings;

d) Valves fitted on collision bulkhead;

e) Clean ballast lines through cargo oil tanks to forward ballast tanks;

f) Bilge lines in tanks;

g) Outlet valves of fuel and lubricating oil tanks with static head.

Section 5

Plastic Pipes and Fittings

5.1 General

5.1.1 Proposals to use plastics material in shipboard piping systems will be considered in relation to the properties of the materials, the operating conditions of temperature and pressure, and the intended service. Any proposed service for plastics pipes not mentioned in these Rules is to be submitted for special consideration.

5.1.2 Attention is also drawn to the Guidelines for the Application of Plastic Pipes on Ships contained in IMO Resolution A.753(18).

5.1.3 Plastic pipes and fittings will, in general, be accepted in Class III piping systems. Proposals for the use of plastics in Class I and Class II piping systems will be specially considered.

5.1.4 These requirements are not applicable to flexible pipes and hoses and mechanical couplings used in metallic piping systems.

5.1.5 Piping systems made of thermoplastic materials, such as polyethylene (PE), polypropylene (PP), polybutylene (PB) and intended for non-essential services are to meet the requirements of recognized standards and that of 5.8 and 5.9. However the safety aspects due to fire will require to be considered.

5.1.6 The use of plastics may be restricted by statutory requirements of the National Authority of the country in which the ship is to be registered.

5.1.7 The specification of piping is to be in accordance with a recognized national or international standard acceptable to IRS. In addition, requirements given in 5.3 to 5.6 are to be complied with.

5.2 Terms and definitions

5.2.1 "Plastic(s)" means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and fibre reinforced plastics - FRP.

5.2.2 "Pipes/piping systems" means those made of plastic(s) and include the pipes, fittings, system joints, method of joining and any internal or external liners, coverings and coatings required to comply with the performance criteria.

5.2.3 "Joint" means joining pipes by adhesive bonding, laminating, welding, etc.

5.2.4 "Fittings" means bends, elbows, fabricated branch pieces etc. of plastic materials.

5.2.5 "Nominal pressure" means the maximum permissible working pressure which should be determined in accordance with the requirements in 5.3.3.

5.2.6 "Fire endurance" means the capability of piping to maintain its strength and integrity (i.e. capable of performing its intended function) for some predetermined period of time while exposed to fire.

5.3 Strength

5.3.1 The strength of the pipes is to be determined by hydrostatic pressure tests to failure on representative sizes of the pipe.

5.3.2 The strength of fittings and joints is to be not less than that of the pipes.

5.3.3 The nominal pressure is to be determined from the following conditions :

a) Internal Pressure

For an internal pressure the nominal pressure, Pn, is to be lesser of the following :

$$\text{Pn Int} \leq \frac{\text{Psth}}{4}$$

or

$$\text{Pn Int} \leq \frac{\text{Plth}}{2.5}$$

where,

Psth = short-term hydrostatic test failure pressure;

Plth = long-term hydrostatic test failure pressure (> 100,000 h)

b) For an external pressure the nominal pressure, Pn, is to be as under :

$$\text{Pn ext} \leq \frac{\text{Pcol}}{3}$$

where,

Pcol = pipe collapse pressure.

5.3.4 In no case is the collapse pressure to be less than 3 bar.

5.3.5 The maximum working external pressure is a sum of the vacuum inside the pipe and a head of liquid acting on the outside of the pipe.

5.3.6 The maximum permissible working pressure is to be specified with due regard for maximum possible working temperatures in accordance with Manufacturer's recommendations.

5.3.7 The thickness of pipes is in no case to be less than that specified in Table 5.3.1.

Table 5.3.1 : Minimum wall thickness for plastic pipes

External diameter D [mm]	Minimum wall thickness [mm]	External diameter D [mm]	Minimum wall thickness [mm]
10.2 to 17.2	1.0	219.1	2.6
21.3 to 48.3	1.6	273.0	2.9
60.3 to 88.9	2.0	323.9 to 406.4	3.6
114.3 to 168.3	2.3	Over 406.4	4.0
Note : The external diameters and thicknesses have been selected from ISO 1127 : 1980. For pipes covered by other standards, slightly less thicknesses may be accepted.			

5.4 Axial strength

5.4.1 The sum of the longitudinal stresses due to pressure, weight and other loads is not to exceed the allowable stress in the longitudinal direction.

5.4.2 In the case of fibre reinforced plastic pipes, the sum of the longitudinal stresses is not to exceed half of the nominal circumferential stress derived from the nominal internal pressure condition (See 5.3.3).

5.5 Impact resistance

5.5.1 Plastic pipes and joints are to have a minimum resistance to impact in accordance with recognised national or international standards such as ASTM D.2444 or equivalent.
5.5.2 After the test the specimen is to be subjected to hydrostatic pressure equal to 2.5 times the design pressure for at least 1 hour.

5.6 Temperature

5.6.1 The permissible working temperature depending on the working pressure is to be in accordance with Manufacturer's recommendations, but in each case it is to be at least 20°C lower than the minimum heat distortion temperature of the pipe material, determined according to ISO 75 method A, or equivalent.

5.6.2 The minimum heat distortion temperature is to be not less than 80°C.

5.7 Requirements for pipes/piping systems depending on service and/or locations

5.7.1 Fire endurance

5.7.1.1 Pipes and their associated fittings whose integrity is essential to the safety of ships are required to meet the minimum fire endurance requirements of Appendix 1 or 2, as applicable, of IMO Res A.753(18).

5.7.1.2 Depending on the capability of a piping system to maintain its strength and integrity, there exist three different levels of fire endurance for piping systems.

a) Level 1. Piping having passed the fire endurance test specified in Appendix 1 of IMO Res A.753(18) for a duration of a minimum of one hour without loss of integrity in the dry condition is considered to meet level 1 fire endurance standard (L1).

b) Level 2. Piping having passed the fire endurance test specified in Appendix 1 of IMO Res A.753(18) for a duration of a minimum of 30 minutes in the dry condition is considered to meet level 2 fire endurance standard (L2).

c) Level 3. Piping having passed the fire endurance test specified in Appendix 2 of IMO Res A.753(18) for a duration of a minimum of 30 minutes in the wet condition is considered to meet level 3 fire endurance standard (L3).

5.7.1.3 Permitted use of piping depending on fire endurance, location and piping system is given in Table 5.7.1 "Fire Endurance Requirements Matrix".

5.7.2 Flame spread

5.7.2.1 All pipes, except those fitted on open decks and within tanks, cofferdams, pipe tunnels and ducts are to have low surface flame spread characteristics not exceeding average values listed in IMO Res. A.653(16).

5.7.2.2 Surface flame spread characteristics are to be determined using the procedure given in IMO Res. A.653(16) with regard to the modifications due to the curvilinear pipe surfaces as listed in Appendix 3 of IMO Res. A.753(18).

5.7.3 Fire protection coatings

5.7.3.1 Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance level required, it is to meet the following requirements:

a) The pipes are generally to be delivered from the manufacturer with the protective coating on.

b) The fire protection properties of the coating are not to be diminished when exposed to salt water, oil or bilge slops. It is to be demonstrated that the coating is resistant to products likely to come into contact with the piping.

c) In considering fire protection coatings, such characteristics as thermal expansion, resistance against vibrations and elasticity are to be taken into account.

d) The fire protection coatings are to have sufficient resistance to impact to retain their integrity.

5.7.4 Electrical conductivity

Where electrical conductivity is to be ensured, the resistance of the pipes and fittings is not to exceed 1 x 105 Ohm/m.

Table 5.7.1 : Fire endurance requirements matrix

Sr. No.	Piping Systems	Location										
		A	B	C	D	E	F	G	H	I	J	K
		Machinery spaces of Category A	Other machinery spaces & pump rooms	Cargo pump rooms	Ro/Ro cargo holds	Other dry cargo holds	Cargo tanks	Fuel oil tanks	Ballast water tanks	Cofferdams void spaces pipe tunnel and ducts	Accommoda-tion service and control spaces	Open decks
1	2	3	4	5	6	7	8	9	10	11	12	13
CARGO (FLAMMABLE CARGOES f.p. ≤ 60°C												
1.	Cargo lines	NA	NA	L1	NA	NA	O	NA	O[10]	O	NA	L1[2]
2.	Crude oil washing lines	NA	NA	L1	NA	NA	O	NA	O[10]	O	NA	L1[2]
3.	Vent lines	NA	NA	NA	NA	NA	O	NA	O[10]	O	NA	X
INERT GAS												
4.	Water seal effluent line	NA	NA	O[1]	NA	NA	O[1]	O[1]	O[1]	O[1]	NA	O
5.	Scrubber effluent line	O[1]	O[1]	NA	NA	NA	NA	NA	O[1]	O[1]	NA	O
6.	Main line	O	O	L1	NA	NA	NA	NA	NA	O	NA	L1[6]
7.	Distribution lines	NA	NA	L1	NA	NA	O	NA	NA	O	NA	L1[2]
FLAMMABLE LIQUIDS (f.p. > 60°C)												
8.	Cargo lines	X	X	L1	X	X	NA[3]	O	O[10]	O	NA	L1
9.	Fuel oil	X	X	L1	X	X	NA[3]	O	O	O	L1	L1
10.	Lubricating	X	X	L1	X	X	NA	NA	NA	O	L1	L1
11.	Hydraulic oil	X	X	L1	X	X	O	O	O	O	L1	L1
SEAWATER[1]												
12.	Bilge main & branches	L1[7]	L1[7]	L1	X	X	NA	O	O	O	NA	L1
13.	Fire main & water spray	L1	L1	L1	X	NA	NA	NA	O	O	X	L1
14.	Foam system	L1	L1	L1	NA	NA	NA	NA	NA	O	L1	L1
15.	Sprinkler system	L1	L1	L3	X	NA	NA	NA	O	O	L3	L3
16.	Ballast	L3	L1	L3	L3	X	O[10]	O	O	O	L2	L2
17.	Cooling water, essential services	L3	L3	NA	NA	NA	NA	NA	O	O	NA	L2
18.	Tank cleaning services fixed machines	NA	NA	L3	NA	NA	O	NA	O	O	NA	L3[2]
19.	Non-essential systems	O	O	O	O	O	NA	O	O	O	O	O
FRESH WATER												
20.	Cooling water essential	L3	L3	NA	NA	NA	NA	O	O	O	L3	L3
21.	Condensate return	L3	L3	L3	O	O	NA	NA	NA	O	O	O
22.	Non-essential systems	O	O	O	O	O	NA	O	O	O	O	O

Table 5.7.1 : Fire endurance requirements matrix (Contd.)

Sr. No.	Piping Systems	Location										
		A	B	C	D	E	F	G	H	I	J	K
		Machinery spaces of Category A	Other machinery spaces & pump rooms	Cargo pump rooms	Ro/Ro cargo holds	Other dry cargo holds	Cargo tanks	Fuel oil tanks	Ballast water tanks	Cofferdams void spaces pipe tunnel and ducts	Accommoda-tion service and control spaces	Open decks
1	2	3	4	5	6	7	8	9	10	11	12	13
SANITARY/DRAINS/SCUPPERS												
23.	Deck drains (internal)	L1[4]	L1[4]	NA	L1[4]	O	NA	O	O	O	O	O
24.	Sanitary drains (internal)	O	O	NA	O	O	NA	O	O	O	O	O
25.	Scuppers and discharges (overboard)	O[1,8]	O[1,8]	O[1,8]	O[1,8]	O[1,8]	O	O	O	O	O[1,8]	O
SOUNDING/AIR												
26.	Water tanks/dry spaces	O	O	O	O	O	O[10]	O	O	O	O	O
27.	Oil tanks (f.p. > 60°C)	X	X	X	X	X	X[3]	O	O[10]	O	X	X
MISCELLANEOUS												
28.	Control air	L1[5]	L1[5]	L1[5]	L1[5]	L1[5]	NA	O	O	O	L1[5]	L1[5]
29.	Service air (non-essential)	O	O	O	O	O	NA	O	O	O	O	O
30.	Brine	O	O	NA	O	O	NA	NA	NA	O	O	O
31.	Auxiliary low pressure steam (≤ 7 bar)	L2	L2	O[9]	O[9]	O[9]	O	O	O	O	O[9]	O[9]

Abbreviations:

L1 : Fire endurance test (appendix 1) in dry conditions, 60 min
L2 : Fire endurance test (appendix 1) in dry conditions, 30 min
L3 : Fire endurance test (appendix 2) in wet conditions, 30 min
O : No fire endurance test required
NA : Not applicable
X : Metallic materials having a melting point greater than 925°C

Footnotes:

1 Where non-metallic piping is use, remotely controlled valves to be provided at ship's side (valve is to be controlled from outside space).

2 Remote closing valves to be provided at the cargo tanks.

3 When cargo tanks contain flammable liquids with f.p. > 60°C, "O" may replace "NA" or "X".

4 For drains serving only the space concerned, "O" may replace "L1".

5 When controlling functions are not required by statutory requirements or guidelines, "O" may replace "L1".

6 For pipe between machinery space and deck water seal, "O" may replace "L1".

7 For passenger vessels, "X" is to replace "L1".

8 Scuppers serving open decks in positions 1 and 2, as defined in Regulation 13 of the International Convention on Load Lines, 1966 should be "X" throughout unless fitted at the upper end with the means of closing capable of being operated from a position above the freeboard deck in order to prevent downflooding.

9 For essential services, such as fuel oil tank heating and ship's whistle, "X" is to replace "O".

10 For tankers where compliance with paragraph 3 (f) of Regulation 13F of Annex I of MARPOL 73/78 is required, "NA" is to replace "O".

Location Definitions:

A	Machinery spaces of Category A	Machinery spaces of Category A as defined in SOLAS* Regulation II-2/3.19.
B	Other machinery spaces and pump rooms	Spaces, other than Category A machinery spaces and cargo pump rooms, containing propulsion machinery, boilers, steam and internal combustion engines, generators and major electrical machinery, pumps, oil filling stations, refrigerating, stabilising, ventilation and air-conditioning machinery and similar spaces and trunks to such spaces.
C	Cargo pump rooms	Spaces containing cargo pumps and entrances and trunks to such spaces.
D	Ro-ro cargo holds	Ro-ro cargo holds are ro-ro cargo spaces and special category spaces as defined in SOLAS* Regulation II-2/3.14 and 3.18.
E	Other dry cargo holds	All spaces other than ro-ro cargo holds used for non-liquid cargo and trunks to such spaces.
F	Cargo tanks	All spaces used for liquid cargo and trunks to such spaces.
G	Fuel oil tanks	All spaces used for fuel oil (excluding cargo tanks) and trunks to such spaces.
H	Ballast water tanks	All spaces used for ballast water and trunks to such spaces.
I	Cofferdams, voids, etc.	Cofferdams and voids are those empty spaces between two bulkheads separating two adjacent compartments.
J	Accommodation, service	Accommodation spaces, service spaces and control stations as defined in SOLAS* Regulation II-2/3.10, 3.12, 3.22.
K	Open decks	Open deck spaces as defined in SOLAS* Regulation II-2/26.2.2(5).

* SOLAS 74 as amended by the 1978 SOLAS Protocol and the 1981 and 1983 amendments (consolidated text).

5.8 Material approval and quality control during manufacture

5.8.1 Prototypes of pipes and fittings are to be tested to determine short-term and long-term design strength, fire endurance and low surface flame spread characteristics, electrical resistance (for electrically conductive pipes), impact resistance in accordance with this Section.

5.8.2 For prototype testing representative samples of pipes and fittings are to be selected to the satisfaction of the Classification Society.

5.8.3 The Manufacturer is to have quality system that meets ISO 9000 series standards or equivalent. The quality system is to consist of elements necessary to ensure that pipes and fittings are produced with consistent and uniform mechanical and physical properties.

5.8.4 Each pipe and fitting made by hand lay up technique, is to be tested by the Manufacturer at a hydrostatic pressure not less than 1.5 times the nominal pressure. For other pipes and fittings, manufactured in accordance with the recognized standards by machined processes (e.g. ‘Continuous extruding’, ‘Filament wound and centrifugally cast’) the hydrostatic pressure test may be carried out in accordance with requirements stipulated in the relevant standard to which the pipe or fittings are manufactured, provided that there is an effective quality system in place at manufacturer’s works.

5.8.5 Piping and fittings are to be permanently marked with identification. Identification is to include pressure ratings, the design standards that the pipe or fitting is manufactured in accordance with and the material of which the pipe or fitting is made.

5.8.6 In case the Manufacturer does not have an approved quality system complying with ISO 9000 series or equivalent, pipes and fittings are to be tested in accordance with this Section to the satisfaction of the attending surveyors for every batch of pipes.

5.8.7 Depending upon the intended application, IRS may require, pressure testing of each pipe and/or fitting.

5.9 Installation

5.9.1 Supports

5.9.1.1 Selection and spacing of pipe supports in shipboard systems are to be determined as a function of allowable stresses and maximum deflection criteria. Support spacing is not to be greater than the pipe Manufacturer's recommended spacing. The selection and spacing of pipe supports are to take into account pipe dimensions, mechanical and physical properties of the pipe material, mass of pipe and contained fluid, external pressure, operating temperature, thermal expansion effects, loads due to external forces, thrust forces, water hammer, vibrations, maximum accelerations to which the system may be subjected. Combination of loads is to be considered.

5.9.1.2 Each support is to evenly distribute the load of the pipe and its contents over the full width of the support. Measures are to be taken to minimise wear of the pipes where they contact the supports.

5.9.1.3 Heavy components in the piping system such as valves and expansion joints are to be independently supported.

5.9.2 Expansion

5.9.2.1 Suitable provision is to be made in each pipeline to allow for relative movement between pipes made of plastic and the steel structure, having due regard to:

i) the difference in the coefficients of thermal expansion;

ii) deformations of the ship's hull and its structure.

5.9.2.2 When calculating the thermal expansions, account is to be taken of the system working temperature and the temperature at which assembly is performed.

5.9.3 External loads

5.9.3.1 When installing the piping, allowance is to be made for temporary point loads, where applicable. Such allowances are to include at least the force exerted by a load (person) of 100 kg at mid-span on any pipe of more than 100 mm nominal outside diameter.

5.9.3.2 Besides for providing adequate robustness for all piping including open-ended piping a minimum wall thickness, complying with 5.3.7 may require to be increased taking into account the conditions encountered during service on board ships.

5.9.3.3 Pipes are to be protected from mechanical damage where necessary.

5.9.4 Strength of connections

5.9.4.1 The strength of connections is to be not less than that of the piping system in which they are installed.

5.9.4.2 Pipes may be assembled using adhesive-bonded, welded, flanged or other joints.

5.9.4.3 Adhesive, when used for joint assembly, are to be suitable for providing a permanent seal between the pipes and fittings throughout the temperature and pressure range of the intended application.

5.9.4.4 Tightening of joints is to be performed in accordance with Manufacturers' instructions.

5.9.5 Installation of conductive pipes

5.9.5.1 In piping systems for fluids with conductivity less than 1000 pico siemens per metre (pS/m) such as refined products and distillates use is to be made of conductive pipes.

5.9.5.2 Regardless of the fluid being conveyed, plastic piping is to be electrically conductive if the piping passes through a hazardous area. The resistance to earth from any point in the piping system is not to exceed 1×10^6 Ohm. It is preferred that pipes and fittings be homogeneously conductive. Pipes and fittings having conductive layers are to be protected against a possibility of spark damage to the pipe wall. Satisfactory earthing is to be provided.

5.9.5.3 After completion of the installation, the resistance to earth is to be verified. Earthing wires are to be accessible for inspection.

5.9.6 Application of fire protection coatings

5.9.6.1 Fire protection coatings are to be applied on the joints, where necessary for meeting the required fire endurance for 5.7.3, after performing hydrostatic pressure tests of the piping system.

5.9.6.2 The fire protection coatings are to be applied in accordance with Manufacturer's recommendations, using a procedure approved in each particular case.

5.9.7 Penetration of divisions

5.9.7.1 Where plastic pipes pass through "A" or "B" class divisions, arrangements are to be made to ensure that the fire endurance is not impaired. These arrangements are to be tested in accordance with Recommendations for fire test procedures for "A", "B" and "F" bulkheads (Resolution A.754(18) as amended).

5.9.7.2 When plastic pipes pass through watertight bulkheads or decks, the watertight integrity of the bulkhead or deck is to be maintained.

5.9.7.3 If the bulkhead or deck is also a fire division and destruction by fire of plastic pipes may cause the inflow of liquid from tanks, a metallic shut-off valve operable from above the freeboard deck should be fitted at the bulkhead or deck.

5.9.8 Control during installation

5.9.8.1 Installation is to be in accordance with the Manufacturer's guidelines.

5.9.8.2 Prior to commencing the work, joining techniques are to be approved by the Classification Society.

5.9.8.3 The tests and examinations specified in this Section are to be completed before shipboard piping installation commences.

5.9.8.4 The personnel performing this work are to be properly qualified and certified to the satisfaction of the Classification Society.

5.9.8.5 The procedure of making bonds is to include:

i) materials used,

ii) tools and fixtures,

iii) joint preparation requirements,

iv) cure temperature,

v) dimensional requirements and tolerances, and

vi) tests acceptance criteria upon completion of the assembly.

5.9.8.6 Any change in the bonding procedure which will affect the physical and mechanical properties of the joint is to require the procedure to be requalified.

5.9.9 Bonding procedure quality testing

5.9.9.1 A test assembly is to be fabricated in accordance with the procedure to be qualified and it is to consist of at least one pipe-to-pipe joint and one pipe-to-fitting joint.

5.9.9.2 When the test assembly has been cured, it is to be subjected to a hydrostatic test pressure at a safety factor 2.5 times the design pressure of the test assembly, for not less than one hour. No leakage or separation of joints is allowed. The test is to be conducted so that the joint is loaded in both longitudinal and circumferential directions.

5.9.9.3 Selection of the pipes used for test assembly, is to be in accordance with the following:

a) When the largest size to be joined is 200 mm nominal outside diameter, or smaller, the test assembly is to be the largest piping size to be joined.

b) When the largest size to be joined is greater than 200 mm nominal outside diameter, the size of the test assembly is to be either 200 mm or 25% of the largest piping size to be joined, whichever is greater.

5.9.9.4 When conducting performance qualifications, each bonder and each bonding operator are to make up test assemblies, the size and number of which are to be as required above.

5.9.10 Testing after installation on board

5.9.10.1 Piping systems for essential services are to be subjected to a test pressure not less than 1.5 times the design pressure or 4 bar whichever is greater.

5.9.10.2 Piping systems for non-essential services are to be checked for leakage under operational conditions.

5.9.10.3 For piping required to be electrically conductive, earthing is to be checked and random resistance testing is to be conducted.

5.10 Test specification for plastic pipes

5.10.1 Scope

Section 5.10 contains requirements for the Type Approval of plastic pipes. It is applicable to rigid pipes, pipe joints and fittings.

5.10.2 Documentation

The following information for the plastic pipes, fittings and joints is to be submitted for consideration and approval:

I. General information

1) Pipe and fitting dimensions
2) Maximum internal and external working pressure
3) Working temperature range
4) Intended services and installation locations
5) The level of fire endurance
6) If electrically conductive
7) Fluids Intended to be carried
8) Limits on flow rates
9) Serviceable life
10) Installation instructions
11) Details of marking.

II. Drawings and supporting documentation:

1) Certificates and reports for relevant tests previously carried out.
2) Details of relevant standards.
3) All relevant design drawings, catalogues, data sheets, calculations and functional descriptions.
4) Fully detailed section assembly drawings showing pipe, fittings and pipe connections.

III. Materials

1) The resin used for the construction of plastic pipes and fittings.
2) Catalyst and accelerator types and concentration employed in the case of reinforced polyester resin pipes or hardeners where epoxide resins are employed.
3) A statement of all reinforcements employed where the reference number does not identify the mass per unit area or the text number of a roving used in a filament winding process, these are to be detailed.
4) Full information regarding the type of gel-coat or thermoplastic liner employed during construction, as appropriate.
5) Cure/post-cure conditions. The cure and post-cure temperatures and time required and resin/reinforcement ratio.
6) Winding angle and orientation.

5.10.3 Testing

Testing is to demonstrate that pipes, fittings and joints for which Type Approval is sought comply with requirement of Section 5.

The standards to be used for testing of pipes, joints and fittings are given in Table 5.10.1 and Table 5.10.2.

Table 5.10.1 : Typical standards for general requirements for all systems

	Test	**Rule clause no. / Typical Standard**	**Remarks**
1	Internal pressure [(1)]	5.3.3a) ASTM D 1599 ASTM D 2992 ISO 15493 or equivalent	Top, Middle, Bottom (of range) Tests are to be carried out on pipe spools made of different pipe sizes, fittings and pipe connections
2	External pressure [(1)]	5.3.3b) ISO 15493 or equivalent	As above, for straight pipes only
3	Axial strength	5.4	As above
4	Load deformation	ASTM D2412 or equivalent	Top, Middle Bottom (of each pressure range)
5	Temperature limitations	ISO 75 Method A GRP piping system: HDT test on each type of resin acc. To ISO 75 method A Thermoplastic piping systems: ISO 75 Method A; ISO 306 Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST) VICAT test according to ISO 2507 Polyesters with an HDT below 80°C should not be used.	Each type of resin
6	Impact resistance	ISO 9854:1994, ISO 9653:1991 ISO 15493 ASTM D2444 or equivalent	Representative sample of each type of construction
7	Ageing	Manufacturer's standard ISO 9142:1990	Each type of construction
8	Fatigue	Manufacturer's standard or service experience	Each type of construction
9	Fluid absorption	ISO 8361:1991	
10	Material compatibility [(2)]	ASTM C581 Manufacturer's standard	

Notes:
(1) Test to be witnessed by IRS Surveyor.
(2) If applicable.

Table 5.10.2 : Typical standards for additional requirements depending on service and/or locations of piping

	Test	Rule clause no. / Typical Standard	Remarks
1	Fire endurance (1) (2)	IMO Res. A753(18), Appendix 1,2	Representative samples of each type of construction and type of pipe connection
2	Flame spread (1) (2)	5.7.2	Representative samples of each type of construction
3	Smoke generation (2)	IMO Fire Test Procedures Code	Representative samples of each type of construction
4	Toxicity (2)	IMO Fire Test Procedures Code	Representative samples of each type of construction
5	Electrical conductivity (1) (2)	ASTM F1173-95 or ASTM D257, NS6126 para 11.2 or equivalent	Representative samples of each type of construction

Notes:
(1) Test to be witnessed by IRS Surveyor.
(2) If applicable.

Tests 1, 2 and 5 of above table are optional. However, if carried out, the range of approved applications for the pipes will be limited accordingly (See Table 5.7.1).

Section 6

Flexible Hoses

6.1 Definition

6.1.1 Flexible hose assembly is defined as short length of integral metallic or non-metallic hose with prefabricated end fittings ready for installation.

6.2 Scope

6.2.1 The requirements of 6.3 to 6.6 apply to flexible hoses of metallic or non-metallic material intended for a permanent connection between a fixed piping system and items of machinery where necessary to accommodate relative movement between the machinery and the fixed piping system. The requirements may also be applied to temporarily connected flexible hoses or hoses of portable equipment.

6.2.2 Flexible hose assemblies as defined in 6.1.1 may be accepted for use in oil fuel, lubricating, hydraulic and thermal oil systems, fresh water and sea water cooling systems, compressed air systems, bilge and ballast systems and Class III steam systems where they comply with 6.3 to 6.6. Flexible hoses are not accepted in high pressure fuel oil injection systems.

6.2.3 These requirements for flexible hose assemblies are not applicable to hoses intended to be used in fixed fire extinguishing systems.

6.3 Design and construction

6.3.1 Flexible hoses are to be designed and constructed in accordance with recognized National or International Standards. Flexible hoses constructed of rubber or plastics materials and intended for use in bilge, ballast, compressed air, oil fuel, lubricating, hydraulic and thermal oil systems are to incorporate a single double or more closely woven integral wire braid or other suitable material for reinforcement.

Flexible hoses of plastics materials such as Teflon or Nylon, (which are used for the purposes mentioned above), where reinforcement is not possible by incorporating closely woven integral wire braid are to have suitable reinforcing material as far as practicable.

Where rubber or plastic material hoses are to be used in oil supply lines to burners, the hoses are to have external wire braid protection in addition to the reinforcement mentioned above which is provided during manufacturing. Flexible hoses for use in steam systems are to be of metallic construction.

6.3.2 Flexible hoses are to be complete with approved end fittings in accordance with manufacturer's specification. The end connections that do not have a flange are to comply with 2.7 as applicable and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose with particular reference to pressure and impulse tests. Refer Pt.4, Ch.4, 4.8.5.2.

6.3.3 The use of hose clamps and similar types of end attachments is not acceptable for flexible hoses in piping systems for steam, flammable media, starting air systems or for sea water systems where failure may result in flooding. In other piping systems, the use of hose clamps may be accepted where the working pressure is less than 5 bar and provided there are double clamps at each end connection.

6.3.4 Flexible hose assemblies intended for installation in piping systems where pressure pulses and/or high levels of vibration are expected to occur in service, are to be designed for the maximum expected impulse peak pressure and forces due to vibration. The tests required by 6.5 are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to installation.

6.3.5 Flexible hose assemblies constructed of non-metallic materials intended for installation in piping systems for flammable media and sea water systems where failure may result in flooding, are to be of fire-resistant type. Fire resistance is to be demonstrated by testing to ISO 15540 and ISO 15541.

6.3.6 Flexible hose assemblies are to be selected for the intended location and application taking into consideration ambient conditions, compatibility with fluids under working pressure and temperature conditions consistent with the manufacturer's instructions and any requirements given elsewhere in the Rules. (Refer Pt.4, Ch.3, 4.3.5; Pt.4, Ch.6, 3.4; Pt.5, Ch.26, 2.6.10; Pt.5, Ch.29, 2.1.2).

6.4 Installation

6.4.1 In general, flexible hoses are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery / equipment or systems.

6.4.2 Flexible hose assemblies are not to be installed where they may be subjected to torsional deformation (twisting) under normal operating conditions.

6.4.3 The number of flexible hoses, in piping systems mentioned in 6.2.2 is to be kept to minimum and to be limited for the purpose stated in 6.2.1.

6.4.4 Where flexible hoses are intended to be used in piping systems conveying flammable fluids that are in close proximity of heated surfaces the risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated as far as practicable by the use of screens or other similar protection to the satisfaction of the Surveyor.

6.4.5 Flexible hoses are to be installed in clearly visible and readily accessible locations.

6.4.6 The installation of flexible hose assemblies is to be in accordance with the manufacturer's instructions and use limitations with particular attention to the following, if any:

- Orientation
- End connection support (where necessary)
- Avoidance of hose contact that could cause rubbing and abrasion
- Minimum bend radii.

6.5 Tests

6.5.1 Acceptance of flexible hose assemblies is subject to satisfactory prototype testing. Prototype test programmes for flexible hose assemblies are to be submitted to IRS by the manufacturer and are to be sufficiently detailed to demonstrate performance in accordance with the specified standards given in 6.5.2 and 6.5.3.

6.5.2 The tests are, as applicable, to be carried out on different nominal diameters of hose type complete with end fittings for pressure, burst, impulse resistance and fire resistance in accordance with the requirements of the relevant standard. The following standards are to be used as applicable:

- ISO 6802 – Rubber and plastics hoses and hose assemblies with wire reinforcements– Hydraulic impulse test with flexing.

- ISO 6803 – Rubber or plastics hoses and hose assemblies – Hydraulic-pressure impulse test without flexing.

- ISO 15540 – Ships and marine technology – Fire resistance of hose assemblies – Test methods.

- ISO 15541 – Ships and marine technology – Fire resistance of hose assemblies – Requirements for test bench.

- ISO 10380 – Pipe work – Corrugated metal hoses and hose assemblies. Other standards may be accepted where agreed by IRS.

6.5.3 All flexible hose assemblies are to be satisfactorily prototype burst tested to an international standard***** to demonstrate they are able to withstand a pressure not less than four times its design pressure without indication of failure or leakage.

Note : ***** The international standards, e.g. EN or SAE for burst testing of non-metallic hoses, require the pressure to be increased until burst without any holding period at 4 x MWP.

6.6 Marking

6.6.1 Flexible hoses are to be permanently marked by the manufacturer with the following details:

- Hose manufacturer’s name or trademark.
- Date of manufacture (month/year).
- Designation type reference.
- Nominal diameter.
- Pressure rating.
- Temperature rating.

Where a flexible hose assembly is made up of items from different manufacturers, the components are to be clearly identified and traceable to evidence of prototype testing.

Section 7

Hydraulic Tests on Pipes and Fittings

7.1 Hydraulic tests before installation on board

7.1.1 All Class I and II pipes and their associated fittings are to be tested by hydraulic pressure to the Surveyor's satisfaction. Further, all steam, feed, compressed air and fuel oil pipes, together with their fittings, are to be similarly tested where the design pressure is greater than 3.5 bar. The test is to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

7.1.2 Where the design temperature does not exceed 300°C, the test pressure is to be 1.5 times the design pressure.

7.1.3 For steel pipes and integral fittings for use in systems where the design temperature exceeds 300°C, the test pressure is to be as follows but need not exceed twice the design pressure:

$$P_t = 1.5\,P\,\frac{K_{100}}{K_t}\,\text{bar}$$

where,

P_t and P are defined in Sec.1, Cl.1.5.1

K_{100} = allowable stress for 100°C [N/mm^2]

K_t = allowable stress for the design temperature [N/mm^2].

7.1.4 In no case is the membrane stress to exceed 90 per cent of the yield stress at the testing temperature.

7.1.5 All valves and fittings are to be tested in accordance with recognized standards, but not less than 1.5 times the nominal pressure rating at ambient temperature. Valves, cocks and distance pieces intended to be fitted on the ship side below the load waterline are to be hydraulically tested to a pressure not less than 5 bar.

7.1.6 When, for technical reasons, it is not possible to carry out complete hydrotesting before assembly on board for all sections of piping, proposals for testing the remaining/ closing lengths of piping, particularly in respect of the closing seams, are to be submitted for approval.

7.1.7 Pressure testing of small bore pipes (less than 15 mm) may be waived at the discretion of IRS depending on the application.

7.2 Testing after assembly on board

7.2.1 Heating coils in tanks and liquid or gas fuel oil piping are to be tested by hydraulic pressure, after installation on board, to 1.5 times the design pressure but in no case to less than 4 bar.

7.2.2 Where pipes specified in 7.1.1 are butt welded together during assembly on board, they are to be tested by hydraulic pressure in accordance with the requirements of 7.1 after welding. The pipe lengths may be insulated, except in way of the joints made during installation and before hydraulic test is carried out.

7.2.3 The hydraulic test required by 7.2.2 may be omitted provided non- destructive tests by ultrasonic or radiographic methods are carried out on the entire circumference of all butt welds with satisfactory results. Where ultrasonic test has been carried out, the manufacturer is to provide the Surveyor with a signed statement confirming that ultrasonic examination has been carried out by an approved operator and that there were no indications of defects which could be expected to have prejudicial effect on the service performance of the piping.

7.2.4 Where bilge pipes are accepted in way of double bottom tanks or deep tanks, the pipes after fitting are to be tested by hydraulic pressure to the same pressure as the tanks through which they pass.

End of Chapter

Chapter 3

Pumping and Piping

Contents

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to all ships but may be modified for ships classed for restricted services or for special services.

1.1.2 Whilst these requirements are considered to satisfy the relevant requirements of the International Convention for the Safety of Life at Sea, 1974, and applicable amendments, attention should be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

1.1.3 Consideration will be given to special cases or to arrangements which are considered equivalent to those required by Rules.

1.2 Plans

1.2.1 The following plans in diagrammatic form are to be submitted for consideration before proceeding with the work:

a) General arrangement of pumps and piping systems;

b) Oil-fuel filling, transfer and service piping systems;

c) Boiler feed piping systems;

d) Steam piping and condensate piping systems;

e) Bilge and ballast piping systems;

f) Lubricating-oil piping systems;

g) Liquid cargo pumping systems;

h) Hydraulic power piping systems for essential services;

i) Compressed air piping systems;

j) Steering gear piping systems;

k) Sea water and fresh water service piping systems;

l) Vents, sounding and overflow piping systems;

m) Sanitary piping systems;

n) Fire main and fire extinguishing piping systems.

1.2.2 The plans are to include the information like size, wall thickness, maximum working pressure, temperature and material of all pipes, and type, size and material of the valves and fittings.

1.3 Materials

1.3.1 The materials to be used in piping systems are to be suitable for the service intended. In general, except where otherwise stated, pipes, valves and fittings are to be made of steel, cast iron, copper, copper alloy or other approved material. See Ch.2 also.

Materials for pipes carrying corrosive fluids are to be compatible with the fluids being handled and are to be specially considered. See Ch.2, 1.9.5.

1.3.2 Materials sensitive to heat such as aluminium, lead or plastics, are not to be used in systems essential to the safe operation of the ship.

1.4 Valves and cocks

1.4.1 All the valves and cocks are to be so designed and constructed so that the valve covers or glands will not slacken up when the valves are operated.

1.4.2 All the valves are to be designed to close with right hand (clockwise when facing the end of the stem) motion of the wheel of the valve.

1.4.3 All the valves and cocks are to be fitted in places where they are easily accessible at all times and are to be fitted with legible nameplates indicating their function in the system and their installation is to be such that it can be readily observed that they are open or closed.

1.4.4 All the valves and cocks fitted with remote control are to be provided with local manual control independent of the remote operating mechanism. The operation of the local control is not to render the remote control system inoperable.

1.4.5 The valves, cocks and other fittings which are attached directly to plating, which is required to be of watertight construction, are to be secured to the plating by means of studs screwed into the plating and not by bolts passing through clearance holes. Alternatively the studs may be welded to the plating.

1.5 Shipside fittings (other than sanitary discharges and scuppers)

1.5.1 All sea inlet and overboard discharge valves are to be fitted in either of the following ways :

a) directly on the shell plating;

b) to the plating of fabricated steel water boxes of rigid construction integral with the ship's plating;

c) to short, rigid distance pieces welded to the shell plating.

1.5.2 All valves and cocks fitted directly to the shell plating are to have spigots extending through the plating. These spigot on valves may however be omitted, if valves are fitted on pads which themselves form spigots in way of plating.

1.5.3 Boiler blow-down valves or cocks are to have a protection ring fitted on the outside of the shell plating. The spigot of the valve or the cock is to be flush with the outer surface of the protection ring.

1.5.4 Valves and cocks are to be attached to the shell plating by bolts tapped into the plating and fitted with countersunk heads, or by studs screwed into heavy steel pads fitted to the plating. The stud holes are not to penetrate the pad plating.

1.5.5 Ship side valves and fittings, if made of steel or material with low corrosion resistance, are to be suitably protected against wastage.

1.5.6 Gratings are to be fitted at all openings in ship's side for inlet of seawater. The net area through the gratings is to be at least twice the area of the valves connected to the opening. Provision is to be made to clear the gratings by low pressure steam or compressed air.

1.5.7 The scantlings of valves and valve stools fitted with steam, or compressed air clearing connections are to be suitable for the maximum pressure to which the valves and stools may be subjected.

1.6 Piping installation

1.6.1 Heavy pipes and valves are to be so supported that their weight is not taken up by connected pumps and fittings.

1.6.2 Support of the pipes is to be such that detrimental vibrations do not arise in the system.

1.6.3 Where pipes are carried through watertight bulkheads or tank tops, means are to be made to ensure the integrity of the watertightness of the compartment.

1.6.4 As far as possible, installation of pipes for water, oil, exhaust gases from oil engines or steam, is to be avoided near electric switchboards. If this is impracticable, all the joints in pipe line and valves are to be at a safe distance from the switchboards and shielded to prevent damage to switchboard.

1.6.5 Provision is to be made to take care of expansion or contraction stresses in pipes due to temperature stresses or working of the hull.

1.6.6 Expansion pieces of approved type, made of oil resistant re-inforced rubber or other approved material may be used in circulating water systems in machinery spaces.

1.6.7 All piping systems, where a pressure greater than the designed pressure could be developed, are to be protected by suitable relief valves.

1.6.8 All pipes, situated in cargo spaces, fish holds or other spaces, where they can be damaged mechanically, are to be suitably protected.

1.6.9 All pipes which pass through chambers intended for the carriage or storage of refrigerated cargo are to be well insulated. In case the temperature of the chamber is below 0°C the pipes are to be insulated from the ship's structure also, except at positions where the temperature of the ship's structure is always above 0°C and is controlled by outside temperature.

Air refreshing pipes leading to and from refrigerated chambers need not be insulated from the ship's structure.

1.6.10 Deck wash pipes and discharge pipes from the pumps to domestic water tanks are not to pass through cargo holds.

Section 2

Bilge and Ballast Piping Systems

2.1 General

2.1.1 All ships are to be provided with necessary pumps, suction and discharge piping and means of drainage so arranged that any compartment can be pumped out effectively, when the ship is on an even keel and/or designed trim and is either upright or has a list of not more than 5 degrees, through at least one suction, except for machinery spaces where at least two suctions are required, one of which is to be a branch bilge suction and the other is to be a direct bilge suction. Wing suctions will, generally, be necessary for this purpose, except for short narrow compartments, where a single suction may be sufficient.

2.1.2 All passenger ships are to be provided with an efficient bilge pumping plant capable of pumping from and draining any watertight compartment which is neither a permanent oil compartment nor a permanent water compartment under all practicable conditions, after a casualty, whether the ship is upright or listed.

2.2 Drainage of cargo holds

2.2.1 In ships without a double bottom one bilge suction is normally to be provided on each side of the cargo hold, at the after ends. However, if the rise of floor exceeds 5 degrees, one bilge suction at the after end situated as near the centerline as practicable may be accepted.

In ships where the bilge water cannot be entirely drained by suctions as provided above due to the fitting of watertight floors or keelsons, additional suctions may be required. Recesses and cementing/composition are to be so arranged that water in any part of the hold may find its way to the suction pipes easily.

2.2.2 In the holds of ships with double bottom, bilge suctions are to be provided on each side at the after end of the holds. Where the tanktop extends to the shipside, bilge suctions are to be led from bilge wells of at least 0.15 [m^3] capacity each, situated at the after end at each side of the hold. Where the tanktop has inverse camber, an additional bilge suction from a well situated near the centerline is also to be provided. Bilge wells of smaller size may be considered depending on the size of the vessel and the size of the compartment.

If the tanktop is of a design having discontinuities or depressions, the number and position of bilge suctions will be given special consideration.

2.2.3 Ships with one cargo hold, are to have suctions in the fore and after ends of the hold. In ships having two or more holds, bilge suctions are to be fitted in suitable positions in the fore and after ends of holds over 30 [m] in length.

2.3 Drainage from refrigerated cargo spaces

2.3.1 Provision is to be made for the continuous drainage of the inside of all insulated chambers and cooler trays.

2.3.2 Drains which are led from lower holds and cooler trays situated on the tank top are to be fitted with liquid sealed traps and non-return bilge valves.

2.3.3 Drains from 'tween deck chambers and from cooler trays which are situated well above the tank top are to be fitted with liquid sealed traps.

2.3.4 Where drains from separate chambers join a common main, the branch pipes are each to be provided with a liquid sealed trap.

2.3.5 The liquid sealed traps are to be of adequate depth and are to have a pressure head of at least 100 [mm] when connected to air ducts and 50 [mm] otherwise and arrangements are to be made for ready access to the traps for cleaning and refilling with brine.

2.3.6 Sluices, scuppers or drain pipes, which would permit drainage from compartments outside the insulated chambers into the bilges of the latter, are not to be fitted.

2.3.7 Screwed plugs or other means for blanking off scuppers draining insulating chambers and cooler trays are not to be fitted. If, however, it is especially desired to provide means for temporarily closing these scuppers, they may be fitted with shutoff valves controlled from readily accessible positions on a deck above the load waterline. An indicator is to be provided to indicate whether the valve is open or shut.

2.4 Drainage from fore and aft peaks

2.4.1 Where the peaks are used as tanks, a power pump suction is to be led to each tank, except in case of small tanks (generally not exceeding 2 [m^3] used for the carriage of domestic fresh water where hand pumps may be used.

2.4.2 The peaks may be drained by hand pumps provided the peaks are not used as tanks and they are not connected to bilge main. The suction lift is to be well within the capacity of the hand pumps and is not to exceed 7.3 [m].

In case of vessels of length 24 [m] or less and fishing vessels, after peak may be drained by means of a self closing cock situated in a well lighted and accessible position, and draining into engine room or tunnel.

2.4.3 The collision bulkhead is not to be pierced below the bulkhead deck by more than one pipe for dealing with the contents inside the fore peak tank. Where the forepeak is divided into two compartments for carrying two different kinds of liquids, the collision bulkhead may be pierced by two pipes, i.e. one for each compartment provided that there is no practical alternative to piercing by such a second pipe and that having regard to the additional subdivision provided in the forepeak, the safety of the ship is maintained.

2.4.4 The pipe/pipes piercing the collision bulkhead is/are to be provided with screwdown valve/s capable of being operated from above the bulkhead deck/freeboard deck and the chest of the valve is to be secured to the collision bulkhead inside the forepeak tank except as permitted by 2.4.5. An indicator is to be provided to indicate whether the valve is open or shut.

IR2.4.4 Local hand powered operation is required from above the bulkhead deck/freeboard deck for the valve specified above.

2.4.5 Any valve required by 2.4.4 may be fitted on the after side of the collision bulkhead, provided the valve is readily accessible at all times and the space in which it is located is not a cargo space.

2.4.6 In ships other than passenger ships, the valve required by 2.4.3 may be fitted on the after side of the collision bulkhead, provided the valve is readily accessible at all times and is not subject to mechanical damage.

2.5 Drainage from tanks, cofferdams and void spaces

2.5.1 All the tanks except self-draining tanks, whether for water ballast, oil fuel, liquid cargoes etc. are to be provided with suction pipes led to suitable power pumps. The pumping plant is to be so arranged that any water or liquid within any compartment of the ship can be pumped out through atleast one suction, when the ship is on an even keel and/or designed trim and is either upright or has a list of not more than 5 degrees.

2.5.2 Where the length of the ballast tank exceeds 30 [m], an additional suction is to be provided at the forward end of the tank. Where the width of the tank is unusually large, suctions near the centerline in addition to wing suctions may be required.

2.5.3 Suction pipes from the cofferdams and void spaces are to be led to the main bilge line.

2.5.4 In ships where deep tanks may be used for either water ballast or dry cargo, provision is to be made for blanking the water ballast suction and filling when the tank is being used for carrying cargo and for blanking the bilge line when the tank is being used for carriage of water ballast.

2.6 Drainage from spaces above fore and after peaks, chain lockers and above machinery spaces

2.6.1 Provision is to be made for the drainage of chain locker and watertight compartments above the fore peak tank by hand or power pump suctions.

2.6.2 Steering gear compartments or other small enclosed spaces situated above the after peak tank are to be provided with suitable means of drainage, either by hand or power bilge suctions.

2.6.3 If the compartments referred to in 2.6.2 are adequately isolated from the adjacent 'tween decks, they may be drained by scuppers of not less than 38 [mm] bore, discharging into the tunnel (or machinery spaces in case of ships with machinery aft) and fitted with self-closing cocks situated in well lighted and visible positions. These arrangements are not applicable to passenger ships unless they are specially approved in relation to subdivision considerations.

2.7 Drainage from machinery spaces

2.7.1 Machinery spaces with double bottom:

a) Where the inner bottom extends the full length of the engine room forming bilges at the wings, one branch bilge suction and one direct bilge suction will be required at each side. Where the inner bottom extends the full length and breadth of machinery space, one branch and one direct bilge suctions are to be led to each of the two bilge wells, situated one at each side;

b) The capacity of the bilge wells is to be at least 0.15 [m^3];

c) If the inner bottom has inverse camber or discontinuity or depressions formed due to crankpins or other recesses, additional suctions are to be provided.

2.7.2 Machinery spaces without double bottom:

In ships without inner bottom, where the rise of floor is 5 degrees or more, one branch and one direct bilge suctions are to be led to positions as near the center-line as possible. Bilge suctions at wings will be required in all ships having rise of floor less than 5 degrees.

2.7.3 General requirements for machinery spaces:

a) In ships where machinery is situated at the after end, it will generally be necessary to provide suctions at the forward wings in addition to the suctions at the after end of the machinery space;

b) Special means are to be provided to prevent accumulation of bilge water under main propulsion generators and motors;

c) Where the machinery space is divided into watertight compartments, the drainage system for all compartments except for main engine room is to be same as for cargo holds except that one direct bilge suction from each watertight compartment would also be required;

d) The direct bilge suctions in machinery space(s) are to be led to independent power pump(s), and the arrangements are to be such that these direct suctions can be used independently of the main bilge line suctions.

2.7.4 Emergency bilge suction :

a) An emergency bilge suction is to be fitted to the largest independent power pump, the capacity of which is at least equal to the bilge pump. The suction is to be led to a suitable low position in the machinery space fitted with a screw-down non-return valve having the spindle so extended that the hand wheel is at least 450 [mm] above the engine room floor plates. The valve name plate is to be clearly marked - 'EMERGENCY BILGE SUCTION';

b) In motorships, the emergency bilge suction is to be led to the main cooling water pump. The suction is to be the same size as that of the cooling water pump;

c) In steamships, the main sea water circulating pump is to be fitted with an emergency bilge suction. This suction is to have diameter of at least two third of the pump suction;

d) If two or more cooling water pumps are provided for main engine(s), each capable of supplying sufficient cooling water for normal power, only one pump need be fitted with an emergency bilge suction;

e) Where the main circulating pump is not suitable for emergency bilge suction, the emergency bilge suction is to be led to the largest available independent power pump, which is not fitted with a direct bilge suction and is situated in the same compartment;

f) If the pump to which emergency bilge is connected is of self priming type, then the direct bilge suction on the same side as the emergency bilge suction may be omitted except in passenger ships.

2.8 Drainage from tunnel

2.8.1 A bilge suction, connected to the main bilge line is to be provided for draining the tunnel well. This tunnel well may extend to the outer bottom. If the shaft tunnel slopes from aft to forward end, an additional bilge suction at forward end is to be provided.

2.8.2 Internal diameter of the tunnel bilge suction pipe is not to be less than 65 [mm] except for vessels of length less than 60 [m], where tunnel bilge suction pipes of 50 [mm] bore are acceptable.

2.8.3 Where the length of the tunnel is more than 30 [m], bilge suctions are to be provided at both the forward and aft ends.

2.9 Sizes of bilge suctions

2.9.1 The internal diameter of the bilge pipes is not to be less than that found by the following formula to the nearest 5 [mm] commercial size available:

$$dm = 1.68\sqrt{L\,(B + D)} + 25 \text{ [mm]}$$

$$db = 2.15\sqrt{C\,(B + D)} + 25 \text{ [mm]}$$

where,

dm = internal diameter of bilge main [mm];

db = internal diameter of branch bilge [mm];

L = Rule length of ship [m];

B = Moulded breadth of ship [m];

C = Length of the compartment [m];

D = Moulded depth to bulkhead deck [m].

2.9.2 In any case, bilge main suction line and branch bilge suction line diameters are not to be less than 50 [mm] and the diameter of the main bilge line is not be less than that of the branch bilge line.

2.9.3 The internal diameter of the direct bilge suction is not to be less than the main bilge line.

2.9.4 In oil tankers and similar ships, where the engine room pumps do not deal with bilge drainage outside the machinery spaces, the rule diameter of the bilge main may be reduced provided the proposed cross-sectional area of the bilge main is not less than twice that required for the branch bilge suction in machinery spaces.

2.9.5 The area of each branch pipe connecting the bilge main to a distribution chest is to be not less than the sum of the areas required by the rules for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

2.10 Bilge pumps and ejectors

2.10.1 All ships, other than passenger ships, are to be provided with at least two independent power bilge pumps. For ships of length 91.5 [m] and below, one of these pumps may be main engine driven. See 2.13 for requirements regarding passenger ships.

2.10.2 The capacity of each bilge pump is to be sufficient enough to give the water a speed of at least 122 [metres/minute] through the rule size of the main bilge line under normal working conditions.

The capacity of the bilge pump may be found by the following formula :

$Q = 5.75 \times 10^{-3} \times d^2$ [m^3/hour]

where,

Q = Capacity of pump [m^3/hour];

d = rule diameter of bilge main [mm].

2.10.3 In ships, other than passenger ships, where one bilge pump is of slightly less than rule capacity, the deficiency may be made good by an excess capacity of the other pump. In general this deficiency is to be limited to 30 per cent.

2.10.4 An ejector in conjunction with a sea water pump may be accepted as a substitute for independent power bilge pump. This, however, is not acceptable on passenger ships.

2.10.5 Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any pumps so connected is unaffected by the other pumps being in operation at the same time.

2.10.6 General service pumps and ballast pumps may be accepted as independent power bilge pumps, provided :

a) Their capacity is adequate and in accordance with 2.10.2.

b) These pumps, together with the pipelines to which they are connected, are fitted with necessary devices to ensure that there is no risk of entry of water or oil fuel in the holds or machinery spaces.

c) The arrangements are such that at least one of these pumps is immediately available for bilge duty, when required, even when the remaining pumps are in use for other essential duties such as fire fighting.

2.10.7 For bilge pump capacity for ships having closed vehicle and ro-ro spaces and special category spaces, refer Pt.6, Ch.7, Cl. 3.6.1.4 and 3.6.1.5.

2.11 Pump types

2.11.1 The bilge pumps required by the rules are to be of self-priming type, unless an approved priming system is provided for these ships.

2.12 Bilge piping arrangements and fittings

2.12.1 Bilge pipes are not, as far as possible, to pass through double bottom tanks. If unavoidable, such bilge pipes are to be provided with welded joints or heavy flanged joints and are to be tested after fitting to the same pressure as the tanks through which they pass.

2.12.2 The parts of bilge pipes passing through deep tanks, intended to carry water ballast, fresh water, liquid cargo or fuel oil are normally to be contained in a pipe tunnel, but where this is not done, the pipes are to be of heavy gauge with welded or heavy flanged joints. The open ends of such pipes are to be fitted with non-return valves. The pipes are to be tested, after fitting, to a pressure of not less than the maximum head to which the tanks may be subjected.

2.12.3 Expansion bends, not glands, are to be fitted to pipes passing through double bottom tanks or deep tanks.

2.12.4 The intactness of the machinery spaces, bulkheads and of tunnel plating is not to be impaired by fitting of scuppers discharging into machinery spaces or tunnel from adjacent compartments which are situated below the bulkhead deck. These scuppers may, however, be led into a strongly built scupper drain tank situated in the machinery space or tunnel but closed to these spaces and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

a) The scupper tank air pipe is to be led above the bulkhead deck and provision is to be made for ascertaining the level of the water in the tank;

b) Where one tank is used for the drainage of several watertight compartments, the scupper pipes are to be provided with screw-down non- return valves.

2.12.5 No drain valve or cock is to be fitted to the collision bulkhead. Drain valves or cocks are not to be fitted to other watertight bulkheads if alternative means of drainage are practicable. These arrangements are not permissible in passenger ships.

2.12.6 Where drain valves or cocks are fitted to bulkheads other than collision bulkhead, as permitted by 2.12.5, the drain valves or cocks are to be at all times readily accessible and are to be capable of being shut off from positions above the bulkhead deck. Indicators are to be provided to show whether the drains are open or shut.

2.12.7 Bilge pipes which are required for draining cargo or machinery spaces are to be entirely distinct from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried. This does not, however, exclude a bilge ejection connection, a connecting pipe from a pump to its suction valve chest, or a deep tank suction pipe suitably connected through a change-over device to bilge, ballast or oil line.

2.12.8 The arrangement of pumps, valves and piping is to be such that any pump could be opened up for overhaul and repairs without affecting the operation of the other pumps.

2.12.9 The arrangement of valves, pumps, cocks and their pipe connections is to be such as to prevent the possibility of placing one watertight compartment in communication with another, or of cargo spaces, machinery spaces or other dry spaces coming in communication with the sea or the tanks. For this purpose the bilge suction pipe of any pump also having sea suction is to be fitted with a non-return valve which cannot permit communication between the bilges and the sea or the compartments in use as tanks.

2.12.10 Screw-down non-return valves are to be provided in the following fittings :

a) Bilge distribution chest valves;

b) Direct bilge suction and bilge pump connection to main line;

c) Bilge suction hose connections on the pumps or on the main line;

d) Emergency bilge suctions.

2.12.11 Bilge suction pipes from machinery spaces and shaft tunnel, except emergency bilge suction, are to be led from easily accessible mud boxes fitted with straight tail pipes to the bilges. The open ends of the tail pipes are not to be fitted with strum boxes. The mud boxes are to be provided with covers which can be easily opened and closed for cleaning purposes.

2.12.12 Strum boxes are to be fitted to the open ends of bilge suction pipes from the cargo holds. The diameter of holes from these strum boxes is not to be more than 10 [mm] and the total area of the holes is not to be less than twice the area of the pipes.

2.12.13 Where access manholes to bilge wells are necessary, they are to be fitted as near to the suction strums as practicable.

2.12.14 Adequate distance is to be provided between the open ends of suction pipes and bilge well bottom to permit adequate and easy flow of water and to facilitate cleaning.

2.12.15 All the valves, cocks and mud boxes are to be located in easily accessible positions above or at the same level as the floor plates. Where this is unavoidable, they may be fitted immediately below the floor plates provided the floor plates are capable of being opened and closed easily and suitable name plates are fitted indicating the fittings below.

2.12.16 Where relief valves are fitted to pumps having sea connections, these valves are to be fitted in readily visible positions above the platform. The arrangement is to be such that any discharge from the relief valves will also be readily visible.

2.12.17 Where non-return valves are fitted to the open ends of bilge suction pipes in cargo holds in order to decrease the risk of flooding, they are to be of an approved type which does not offer undue obstruction to the flow of water.

2.13 Additional requirements for passenger ships

2.13.1 All passenger ships are to have at least three power bilge pumps connected to the bilge main, one of which may be attached to the propelling unit. Where the bilge pump numeral is 30 or more, one additional independent power pump is to be provided. Sanitary, ballast and general service pumps may be accepted as independent power bilge pumps if fitted with necessary connections to the bilge pumping system.

The bilge pump numeral is to be calculated as follows:

When P_1 is greater than P : bilge pump numeral

$$= 72\left[\frac{M + 2P_1}{V + P_1 - P}\right]$$

in other cases: bilge pump numeral

$$= 72\left[\frac{M + 2P}{V}\right]$$

where,

L_L = the load line length of the ship (metres), as defined in Pt.3, Ch.1, Cl.2.1.9;

M = the volume of the machinery space (cubic metres), as defined in Pt.6, Ch.1, Sec.3 that is below the bulkhead deck; with the addition thereto of the volume of any permanent oil fuel bunkers which may be situated above the inner bottom and forward of, or abaft, the machinery space;

P = the whole volume of the passenger and crew spaces below the bulkhead deck (cubic metres) which are provided for the accommodation and use of passengers and crew, excluding baggage, store, provision and mail rooms;

V = the whole volume of the ship below the bulkhead deck (cubic metres);

P_1 = KN,

where,

N = the number of passengers for which the ship is to be certified, and

K = $0.056L_L$

However, where the value of KN is greater than the sum of P and the whole volume of the actual passenger spaces above the bulkhead deck, P_1 is to be taken as the above sum (i.e. the sum of P and the whole volume of the actual passenger spaces above the bulkhead deck) or two-thirds KN, whichever is the greater.

2.13.2 Where practicable, the power bilge pumps are to be placed in watertight compartments so arranged or situated that these compartments will not readily be flooded by the same damage. If the engines and boilers are in two or more watertight compartments, the pumps available for bilge service are to be distributed throughout these compartments as far as is possible.

2.13.3 On ships 91.5 [m] or more in length or having a bilge pump numeral of 30 or more, the arrangements are to be such that at least one power pump is available for use in all ordinary circumstances in which a ship may be flooded at sea. This requirement will be satisfied if:

a) One of the required pumps is an emergency pump of reliable submersible type having a source of power situated above the bulkhead deck; or

b) The pumps and their sources of power are so disposed throughout the length of the ship that under any condition of flooding which the ship is required to withstand, at least one pump in undamaged compartment will be available.

2.13.4 In passenger ships, independent power bilge pumps situated in machinery spaces are to have direct suctions from these spaces, except that not more than two such suctions are required in any one space, where two or more such suctions are provided there is to be at least one on the port side and one on the starboard side.

2.13.5 Provision is to be made to prevent the compartment served by any bilge suction pipe being flooded in the event of the pipe being severed, or otherwise damaged by collision or grounding in any other compartment. For this purpose where the pipe is at any part situated nearer the side of the ship than one-fifth the breadth of the ship (measured at right angles to the centerline at the level of the deepest subdivision loadline), or in a duct keel, a non-return valve is to be fitted to the pipe in the compartment containing the open end.

For the purpose of 2.13.5 and 2.13.6, 'breadth' means the maximum moulded breadth of the ship at or below the deepest sub-division loadline.

2.13.6 All the distribution boxes, cocks and valves in connection with the bilge pumping arrangements are to be in positions which are accessible at all times under ordinary circumstances. They are to be so arranged that, in the event of flooding, one of the bilge pumps may be operative on any compartment, in addition, damage to a pump or its pipe connecting to the bilge main outboard of a line drawn at one-fifth of the breadth of the ship (measured as per 2.13.5) is not to put the bilge system out of action. If there is only one system of pipes common to all the pumps, the necessary cocks or valves for controlling the bilge suctions must be capable of being operated from above the bulkhead deck. Where in addition to the main bilge pumping system an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating on any compartment under flooding conditions, in that case only the cocks and valves necessary for the operation of the emergency system need be capable of being operated from above the bulkhead deck.

2.13.7 All valves and cocks mentioned in 2.13.6 which can be operated from above the bulkhead deck shall have their controls at their place of operation clearly marked and provided with means to indicate whether they are open or closed.

2.13.8 Where it is necessary to correct large angles of heel, in case of damage, the means adopted, are where practicable, to be self acting, but in any case where controls to cross flooding fittings are provided, they are to be operable from above the bulkhead deck.

2.13.9 Bilge wells constructed in the double bottom in connection with drainage arrangements of holds, etc. are not to extend downwards more than necessary. The depth of the well is in no case to be more than the depth less 457 [mm] (18 inches) of the double bottom at the center line nor is the well to extend below the horizontal plane passing through the point of intersection with the frame line amidships of a transverse diagonal line inclined at 25 degrees to the base line and cutting it at a point one half the ship's moulded breadth from the middle line. A well extending to the outer bottom is, however, permitted at the after end of the shaft tunnel.

2.14 Drainage arrangements on vessels not fitted with propelling machinery

2.14.1 Vessels not fitted with propelling machinery are to be provided effective hand pumps which can be operated from above the bulkhead deck or the highest convenient level which is always available. There is to be one pump for each compartment or two pumps connected to a bilge main having at least one branch to each compartment.

2.15 Ballast system

2.15.1 Provision is to be made for ballasting and deballasting all the ballast tanks by pipe lines which are entirely separate and distinct from pipe lines used for bilging.

2.15.2 Where the length of the ballast tanks exceeds 30 [m], an additional suction is to be provided at the forward end of the tanks. Where the width of the tank is unusually large, suction near the centerline in addition to wing suctions may be required.

Section 3

Vents, Sounding, Overflow and Scuppers and Discharges Piping Systems

3.1 General

3.1.1 Reference to oil in this Section is to be taken to mean oil which has a flash point of 60°C or above (closed cup test).

3.1.2 The portions of vent, overflow and sounding pipes fitted above the weather deck are to be of steel.

3.1.3 Name plates are to be affixed to the upper ends of all vent and sounding pipes.

3.1.4 For vent pipes and sounding pipes passing through refrigerated spaces, see Pt.5.

3.1.5 For design and test heads of tanks see Pt.3.

3.2 Vent pipes

3.2.1 Vent pipes are to be fitted to all tanks, cofferdams, tunnels, sea chests and other compartments which are not fitted with alternative ventilation arrangements.

3.2.2 The vent pipes are to be fitted at the opposite end of the tank to which the filling pipes are placed and/or at the highest part of the tank. Where the tank top is of unusual or irregular profile, special consideration will be given to the number and positions of the vent pipes.

3.2.3 Tanks provided with anodes for cathodic protection, are to be provided with vent pipes at forward and aft ends.

3.2.4 Vent pipes to double bottom tanks, deep tanks extending to the shell plating or tanks which can be run up from the sea and sea chests are to be led above the bulkhead deck.

3.2.5 Air pipes for sea chests are to be fitted with shut off valve directly on sea chest.

3.2.6 Vent pipes to oil fuel and cargo oil tanks, cofferdams, all tanks which can be pumped up, shaft tunnels and pipe tunnels are to be led above the bulkhead deck and to open air.

3.2.7 Vent pipes from lubricating oil storage tanks may terminate in the machinery spaces, provided that the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

3.2.8 The open ends of vent pipes to oil fuel and cargo oil tanks are to be situated where no danger will be incurred from issuing oil or vapour when the tank is being filled.

3.2.9 For details regarding height and closing devices for vent pipes see Pt.3.

3.2.10 The open ends of vent pipes to oil fuel, cargo oil and ballast tanks fitted with anodes for cathodic protection, are to be fitted with a wire gauze diaphragm of incorrodible material which can be readily removed for cleaning. The clear area through the wire gauze is to be at least equal to the area of the vent pipe. Location and arrangement of vent pipes for fuel oil service, settling and lubricating oil tanks is to be such that a broken vent pipe will not directly lead to the risk of ingress of seawater splashes or rainwater.

3.2.11 In the case of all tanks which can be pumped up either by ship's pumps or by shore pumps through a filling main, the total cross-sectional area of the vent pipes to each tank, or of the overflow pipes where an overflow system is provided, is to be not less than 25 per cent greater than the effective area of the respective filling pipes.

3.2.12 Where tanks are fitted with cross flooding connections, the vent pipes are to be of adequate area for these connections.

3.2.13 Vent pipes are not to be less than 50 [mm] bore.

3.2.14 Shaft tunnels and pipe tunnels are to be fitted with vent pipes with an internal diameter of not less than 75 [mm].

3.2.15 Vent pipes are to be self-draining under normal conditions of trim.

3.2.16 The thickness of the exposed portion of the vent pipes are to be as required in Pt.3, Ch.13, 3.2.5.

3.3 Overflow pipes

3.3.1 All tanks which can be pumped up are to be fitted with overflow pipes when the pressure head corresponding to the height of vent pipe is greater than that for which the tanks are suitable or when the sectional area of the vent pipes is less than that required by 3.2.11.

3.3.2 Oil fuel and lubricating oil tanks which can be pumped up and which have openings for fittings, for example - for a float sounding system, are to be fitted with overflow pipes. The tank openings, for such fittings, are to be situated above the highest point of the overflow piping.

3.3.3 In the case of oil fuel and lubricating oil tanks, the overflow pipe is to be led to an overflow tank of adequate capacity or to a storage tank having space reserved for overflow purposes and be in readily visible position. A sight glass is to be provided in the overflow pipe to indicate when the tanks are overflowing. Such sight glasses are to be placed only in the vertical portion of the pipes and be located in a readily visible position. Alternatively, an alarm device is to be provided to give warning either when the tanks are overflowing or when the oil reaches a predetermined level in the tanks.

3.3.4 Overflow pipes from tanks, other than oil fuel, cargo oil and lubricating oil tanks, are to be led to the open or to suitable overflow tanks arranged as in 3.3.3.

3.3.5 Where overflow from tanks, which are used for the alternative carriage of oil and water ballast, are connected to an overflow system, arrangements are to be made to prevent water ballast overflowing in to tanks containing oil.

3.3.6 The arrangement of the vent and/or overflow system is to be such that in the event of any one of the tanks being bilged, tanks situated in other watertight compartments of the ship cannot be flooded through combined vent pipes or the overflow main. In the case of vessels of 24 [m] length and less, fishing vessels and trawlers the arrangement is to be such that in the event of any one of the tanks being bilged, the other tanks cannot be flooded from the sea through combined vent pipes or the overflow main.

3.3.7 Overflow pipes are to be self-draining under normal conditions of trim.

3.3.8 For size of overflow pipes, see 3.2.11.

3.4 Sounding arrangements (Also refer Pt.6, Ch.2, 1.2.for F.O., L.O. and other flammable oils)

3.4.1 All tanks, cofferdams and pipe tunnels are to be provided with sounding pipes or other approved means for ascertaining the level of liquid in the tanks. Means of ascertaining the level of liquid in oil fuel tanks is to be of safe type. Level switches may be used provided they are contained in steel enclosure or other enclosures not destroyed by fire. Bilges of compartments which are not, at all times, readily accessible are to be provided with sounding pipes. The soundings are to be taken as near the suction pipes as practicable.

3.4.2 Oil level gauges may be used for tanks containing lubricating oil, oil fuel or other flammable liquid in place of sounding pipes, subject to the following conditions:

- In passenger ships such gauges should not require penetration below the top of the tank and their failure or overfilling of the tanks will not allow release of their contents; and

- In cargo ships, the failure of level gauges or overfilling of the tank will not allow release of their contents into the space. The use of cylindrical gauge glasses is not acceptable. Flat type glasses may be accepted provided they are of heat resisting quality, adequately supported, protected from mechanical damage and fitted with self closing valves between the gauges and the tanks.

3.4.3 Except as permitted by 3.4.4 sounding pipes are to be led to positions above the bulkhead deck which are at all times accessible. In the case of oil fuel tanks, cargo oil tanks and lubricating oil tanks, the sounding pipes are to be led to safe positions on the open deck. The sounding pipes should not terminate in any space where the risk of ignition from spillage from sounding pipe exists. Sounding pipes are not to terminate in passenger or crew spaces.

3.4.4 Where it is impracticable to comply with 3.4.3 above, short sounding pipes may be fitted in readily accessible positions as indicated in the following:

a) Passenger ships:

- Only to double bottom tanks and cofferdams in machinery spaces.
- All short sounding pipes are to be provided with self-closing cocks as described in Pt.6, Ch.2, 1.2.2.3.5.1.

b) Cargo ships:

- Only to tanks and cofferdams in machinery spaces and shaft tunnels.
- Short sounding pipes to oil fuel, lubricating oil and other flammable oil tanks are to be provided as per Pt.6, Ch.2, 1.2.2.3.51 and 1.2.3.1(a) and (b). Short sounding pipes to other types of tanks and cofferdams may be fitted with screw caps attached by chain to the pipe or with shut-off cocks.

3.4.5 Elbow sounding pipes are not to be used for deep tanks unless the elbows and pipes are situated within closed cofferdams or within tanks containing similar liquids. They may, however, be fitted to other tanks and may be used for sounding bilges, provided that it is not practicable to lead them direct to the tanks or compartments.

a) The elbows are to be of heavy construction and adequately supported;
b) In passenger ships, elbow sounding pipes are not permissible.

3.4.6 Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes. Where slotted pipes having closed ends are employed, the closing plugs are to be of substantial construction.

3.4.7 All sounding pipes are to be not less than 32 [mm] bore. All sounding pipes, whether for compartments or tanks, which pass through refrigerated spaces or the insulation thereof, in which the temperatures contemplated are 0°C or below, are to be not less than 65 [mm] bore.

3.4.8 The upper ends of all sounding pipes are to be provided with efficient closing devices. The sounding pipes are to be arranged as straight as practicable, and if curved, the curvature is to be large enough to permit easy passage of sounding rod/chain.

3.5 Scuppers and discharges (Also refer Pt.3, Ch.13)

3.5.1 Scupper and discharge pipes which are not required to be of substantial thickness in accordance with Pt.3 are to be at least 4.5 [mm] thick for pipes of 155 [mm] external diameter and less; and 6.0 [mm] for pipes of external diameter of 230 [mm] and more, intermediate sizes are to be determined by linear interpolation.

3.5.2 Scupper and discharge pipes which are required to be of substantial thickness in accordance with Pt.3 are to be at least of following thickness:

- 7 [mm] thick for pipes of external diameter of equal to or less than 80 [mm];
- 10 [mm] thick for pipes of external diameter equal to 180 [mm];
- 12.5 [mm] thick for pipes of external diameter equal to or more than 220 [mm];

Intermediate sizes are to be determined by linear interpolation.

3.5.3 Overboard discharges are to be so located as to prevent any discharge of water into the life boats.

3.6 Water level detectors on single hold cargo ships other than bulk carriers

3.6.1 Ships of load line length L_{LL} (see Pt.3, Ch.1 for definition of L_{LL}) less than 80 [m] and having a single cargo hold below the freeboard deck or cargo holds below the freeboard deck which are not separated by at least one full watertight bulkhead, are to be fitted with water level detectors in such cargo hold/s, unless exempted by 3.6.3.

3.6.2 The water level detectors are to:

i) give an audible and visual alarm at the navigation bridge when the water level above the inner bottom in the cargo hold reaches a height of not less than 0.3 [m] and another when such level reaches not more than 15% of the mean depth of the cargo hold; and

ii) be fitted at the aft end of the hold, or above its lowest part where the inner bottom is not parallel to the design waterline. Where webs or partial watertight bulkheads are fitted above the inner bottom, fitting of additional detectors may be required.

3.6.3 The water level detectors required in 3.6.1 need not be fitted in ships having watertight side compartments each side of the cargo hold length extending vertically at least from inner bottom to freeboard deck.

Note : The water level detectors are to be of approved type. For further details regarding performance tests, sensor locations, installation and other testing requirements refer classification notes: “Type approval, installation and testing of water level detectors on bulk carriers and Single Hold Cargo Ships other than Bulk Carriers”.

Section 4

Fuel Oil Systems

4.1 General

4.1.1 Reference to oil in this Section is to be taken to mean oil which has a flash point of 60°C (closed cup test) or above.

4.2 Oil fuel tanks

4.2.1 Oil fuel tanks are to be separated from fresh water and lubricating oil tanks by means of cofferdams. For requirements in respect of protective location of fuel oil tanks, see Pt.3, Ch.1, Sec.1.6.

4.2.2 The clearance spaces between the boilers and tops of the double bottom tanks, and between the boilers and the sides of the storage tanks in which oil fuel and cargo oil is carried, are to be adequate for the free circulation of the air necessary to keep the temperature of the stored oil sufficiently below it's flash point except in the case of tanks complying with arrangement in 4.5.3 Where water tube boilers are installed, there is to be a space of at least 760 [mm] between the tanktop and the underside of the pans forming the bottom of the combustion spaces. The boilers are to be adequately lagged.

4.2.3 Oil fuel tanks are not to be located directly above the boilers or other highly heated surfaces.

4.2.4 Minimum two fuel oil service tanks for each type of fuel used on board necessary for propulsion and vital systems or equivalent arrangements (See Fig. 4.2.4 for equivalent arrangement) are to be provided with a capacity of at least 8 hours at maximum continuous rating of the propulsion plant and normal operating load of the generating plant.

Fig.4.2.4 : 'Equivalent arrangement' for F.O. service tanks (Refer Clause 4.2.4)

A) Main and auxiliary engines and boilers operating on heavy fuel (one fuel ship)

Rule requirements

HFO Serv Tank Capacity for at least 8.h each Main Eng + Aux. Eng + Aux Boiler	HFO Serv Tank Capacity for at least 8.h each Main Eng + Aux. Eng + Aux Boiler	MDO Tank For initial cold starting or repair work of engines/Boiler

Equivalent arrangements

HFO Serv Tank Capacity for at least 8.h each Main Eng + Aux. Eng + Aux Boiler	MDO Serv Tank Capacity for at least 8.h each Main Eng + Aux. Eng + Aux Boiler

The above arrangement only applies where main and auxiliary engines can operate with heavy fuel oil under all load conditions and, in the case of main engines, during manoeuvring.

For pilot burners of auxiliary boilers if provided, an additional MDO tank for 8 h operation may be necessary.

B) Main engines and boilers on HFO and aux. Engines on MDO (two fuel ship)

Rule requirement

HFO Serv Tank Capacity for at least 8.h each Main Eng + Aux Boiler	HFO Serv Tank Capacity for at least 8.h each Main Eng + Aux Boiler	MDO Serv Tank Capacity for at least 8.h each Aux. Eng	MDO Serv Tank Capacity for at least 8.h each Aux. Eng

Equivalent arrangement

HFO Serv Tank Capacity for at least 8.h each Main Eng + Aux Boiler	MDO Serv Tank Capacity for at least the highest of : 8h each Aux. Eng + Aux. Boiler or 4h each Main Eng + Aux. Eng + Aux Boiler	MDO Serv Tank Capacity for at least the highest of : 8h each Aux. Eng + Aux Boiler or 4h each Main Eng + Aux. Eng + Aux Boiler

Fig.4.2.4 : (Contd.)

Notes:

1. The arrangements in A) and B) above apply, provided the propulsion and vital systems which use two types of fuel, support rapid fuel change over and are capable of operating in all normal operating conditions at sea with both types of fuel (MDO and HFO)

2. Service tank is a fuel oil tank which contains only fuel of a quality ready for use, i.e. fuel of a grade and quality that meets the specification required by the equipment manufacturer. A service tank is to be declared as such and not to be used for any other purpose.

3. Use of a settling tank with or without purifiers alone and one service tank is not acceptable as an "equivalent arrangement" to two service tanks.

4. The equivalent arrangements described above are the interpretations followed by IRS, unless the flag administration has provided a different interpretation.

4.3 Oil fuel piping

4.3.1 Oil fuel pressure pipes are to be led, where practicable, remote from heated surfaces and electrical appliances, but where this is impracticable the pipes are to have a minimum number of joints and are to be led in well lighted and readily visible positions.

4.3.2 Pipes conveying oil heated above 60°C are to be of seamless steel or other approved material having flanged or welded joints.

4.3.3 The flanges are to be machined, and the jointing material, which is to be impervious to oil heated to 150°C, is to be the thinnest possible, so that the flanges are practically metal to metal. The scantlings of the pipes and their flanges are to be suitable for a pressure of at least 14 bar or for the design pressure, whichever is the greater.

4.3.4 The short joining lengths of pipes to the burners from the control valves at the boiler may have cone unions, provided these are of specially robust construction.

4.3.5 Flexible hoses of approved material and design may be used for the burner pipes, provided that spare length complete with couplings, are carried on board.

4.3.6 Transfer, suction and other low pressure oil pipes and all pipes passing through oil storage tanks are to be made of cast iron or steel, having flanged joints suitable for a working pressure of not less than 7 bar. The flanges are to be machined and the jointing material is to be impervious to oil. Where the pipes are of 25 [mm] bore or less, they may be seamless copper or copper alloy, except those which pass through storage tanks.

4.3.7 Pipes for tanks storing fresh water are to be separate and distinct from any pipes which may be used for oil or oily water, and are not to be led through tanks which contain oil, nor are oil pipes to be led through fresh water tanks.

4.3.8 Pipes conveying vegetable oils or similar cargo oils are not to be led through oil fuel tanks, nor are oil fuel pipes to be led through tanks containing such cargoes.

4.3.9 In passenger ships, provision is to be made for the transfer of oil fuel from any oil fuel storage or settling tank to any other oil fuel storage tank.

4.3.10 Where IRS may permit the conveying of oil and combustible liquids through accommodation and service spaces, the pipes conveying oil or combustible liquids are to be of a material approved by IRS having regard to the risk of fire.

4.4 Arrangement of valves, cocks, pumps and fittings

4.4.1 The oil fuel pumping arrangements are to be distinct from other pumping systems as far as practicable and the means provided for preventing dangerous interconnection in service are to be thoroughly effective.

4.4.2 All valves and cocks forming part of the oil fuel installation are to be capable of being controlled from readily accessible positions which, in the engine room and boiler spaces are to be above the working platform.

4.4.3 Every oil fuel suction pipe from a double bottom tank is to be fitted with a valve or a cock.

4.4.4 For oil fuel tanks which are situated above the double bottom tanks, the inlet and outlet, pipes which are connected to the tank at a point lower than the outlet of the overflow pipe or below the top of the tanks without an overflow pipe, are to be fitted with shut off valves located on the tank itself.

4.4.5 In the engine and boiler spaces, valves, mentioned in 4.4.4, are to be capable of being closed locally and from positions outside these spaces which will always be accessible in the event of fire occurring in these spaces. Instructions for closing the valves are to be indicated at the valves and at the remote control positions. The controls for remote operation of the quick closing valve for the emergency generator fuel tank are to be in a separate location from other quick closing valves for tanks in the engine room.

4.4.6 Every oil fuel suction pipe which is led into the engine and boiler spaces, from a tank situated above the double bottom, outside these spaces (including shaft tunnel, pipe tunnel or similar spaces), is to be fitted in the machinery space with a valve controlled as in 4.4.5, except where the valve on the tank is already capable of being closed from an accessible position above the bulkhead deck.

4.4.7 Settling tanks are to be provided with means for draining water from the bottom of the tanks. If the settling tanks are not provided, the oil fuel bunkers or daily service tanks are to be fitted with water drains.

Open drains for removing water from oil tanks are to be fitted with valves or cocks of self-closing type, and suitable provision is to be made for collecting the oily discharge.

4.4.8 Where a power driven pump is necessary for transferring oil fuel, a stand by pump is to be provided and connected ready for use, or, alternatively, emergency connections may be made to another suitable power driven pump.

4.4.9 All pumps which are capable of developing a pressure exceeding the design pressure of the system are to be provided with relief valves. Each relief valve is to be in close circuit, i.e. arranged to discharge back to the suction side of the pump and to effectively limit the pump discharge pressure to the design pressure of the system. Pressure relief valves need not be fitted when the system is secured only by centrifugal pumps so designed that the pressure delivered cannot exceed that for which the piping is designed.

4.4.10 Valves or cocks are to be interposed between the pumps on the suction and discharge pipes in order that any pump may be shut off for opening up and overhaul.

4.4.11 Relief valves are to be fitted on the oil side of the heaters and are to be adjusted to operate at a pressure of 3.5 bar above that of the supply pump relief valves. The discharge from the relief valves is to be led to a safe position.

4.4.12 Drip trays are to be fitted at location where frequent leakage is expected, oil burners at furnace mouths, drain and valves under daily service tanks, filter and all other oil fuel appliances which are required to be opened up frequently for cleaning or adjustment. Where drain pipes are provided from collected leakages, they shall be led to a suitable oil drain tank not forming part of an overflow system.

4.4.13 Where MARPOL Regulation I/12A for protective location of fuel oil tanks applies (see Pt.3, Ch.1, Sec.1.6), the fuel oil lines, suction wells and valves are to satisfy the requirements of paragraph 9 and 10 of the above MARPOL Regulation.

Valves for such fuel oil tanks are to be located above the bottom at distances not less than that required for suction wells` in paragraph 10 of MARPOL Regulation I/12A. Plan showing the location of tanks, suction wells and valves, indicating the distances are to be submitted for approval.

The requirements for locations of oil fuel lines do not apply to fuel oil air escapes and overflow pipes.

4.5 Heating arrangements

4.5.1 Steam heating installation

4.5.1.1 Where steam is used for heating oil fuel, cargo oil or lubricating oil, in bunkers, tanks, heaters or separators, the exhaust drains are to discharge the condensate into an observation tank in a well lighted and accessible position where it can be readily seen whether or not it is free from oil.

4.5.2 Thermal oil installations

4.5.2.1 The inlet and outlet valves of oil-fired thermal oil heaters and exhaust-fired thermal oil heaters is to be controllable from outside the compartment where they are situated.

Alternatively an arrangement for quick gravity drainage of the thermal oil contained in the system into a collecting tank is acceptable.

4.5.2.2 Heating of liquid cargoes with flash points below 60°C shall be arranged by means of a separate secondary system, located completely within the cargo area.

A single circuit system is acceptable on the following conditions:

- system is so arranged that a positive pressure in the coil shall be at least 3 [m] water column above the static head of the cargo when circulating pump is not in operation,

- the thermal oil system expansion tank shall be fitted with high and low level alarms,

- means to be provided in the thermal oil system expansion tank for detection of flammable cargo vapours. Portable equipment is accepted,

- valves for the individual heating coils is to be provided with locking arrangement to ensure that the coils are under static pressure at all times.

4.5.2.3 The thermal oil circulating pumps is to be arranged for emergency stopping from a position outside the space where they are situated.

4.5.2.4 Vents from expansion tanks and thermal oil storage tanks of thermal oil heating plants is to be led to open deck.

4.5.2.5 Exhaust-fired thermal oil heaters

– The heater is to be so designed and installed that all tubes are easily and readily be inspected for signs of corrosion and leakage.

– Visual inspection and tightness testing of the heater tubes is to be not less than the working pressure and is to be carried out annually. Hydraulic testing is to be carried out bi-annually.

– The heater is to be fitted with temperature sensor(s) and an alarm for fire detection.

– A fixed fire extinguishing and cooling system is to be fitted. A drenching system providing copious amounts of water is acceptable. The exhaust ducting below the exhaust boiler is to be arranged for adequate collection and drainage, to prevent water flowing into the diesel engine. The drain is to be led to a suitable location.

4.5.3 Oil fuel in storage tanks is not to be heated to a temperature within 10°C below the flash point of the oil. Where oil fuel in service tanks, settling tanks and any other tanks in the supply system is heated following arrangements are to be provided:

- The length of the vent pipes from such tanks and/or a cooling device is sufficient for cooling the vapours to below 60°C; otherwise the outlet of the vent pipes is to be located at least 3 m away from a source of ignition;

- There are no openings from the vapour space of the fuel tanks in to machinery spaces (bolted manholes are acceptable);

- Any enclosed spaces are not to be located directly above such oil fuel tanks, except for vented cofferdams; and

- Electrical equipment is not to be fitted in the vapour space of the tanks, unless they are certified intrinsically safe.

4.6 Temperature indication

4.6.1 Tanks and heaters in which oil is heated are to be provided with suitable means for ascertaining the temperature of the oil.

4.7 Filling arrangements

4.7.1 The bunkering of the ship is to be carried out through a permanently fitted pipeline, provided with the required fittings and ensuring fuel delivery to all storage tanks. The open end of the filling pipe is to be led to the tank bottom.

In passenger ships fuel bunkering stations are to be isolated from other spaces and are to be efficiently drained and ventilated.

4.7.2 Provision is to be made against over-pressure in the filling pipes, served by pumps on board, and any relief valve fitted for this purpose is to discharge into an overflow tank or other safe position.

4.8 Alternate carriage of oil fuel and water ballast

4.8.1 Where it is intended to carry oil fuel and water ballast in the same tanks alternatively, the valves or cocks connecting the suction pipes of these tanks with the ballast pump and those connecting them with the oil fuel transfer pump are to be so arranged that the oil may be pumped from one tank by the oil fuel pump at the same time as the ballast pump is being used on any other tank.

Where settling or service tanks are fitted, each having a capacity sufficient to permit 12 hour normal service without replenishment, the above requirement may be dispensed with.

4.8.2 Attention is drawn to the statutory requirements issued by the National Authorities in connection with *International Convention for the Prevention of Pollution of the Sea by Oil, 1973/78.*

4.9 Deep tanks for the alternative carriage of oil, water ballast or dry cargo

4.9.1 In the case of deep tanks which can be used for the carriage of oil fuel, cargo oil, water ballast or dry cargo, provision is to be made for blank flanging the oil and water ballast filling and suction pipes, also the steam coils if retained in place, when the tank is used for dry cargo, and for blank flanging the bilge suction pipes when the tanks are used for oil or water ballast.

4.9.2 If the deep tanks are connected to an overflow system, the arrangements are to be such that liquid or vapour from other tanks cannot enter the deep tanks when dry cargo is carried in them.

4.10 Oil fuel burning arrangements

4.10.1 For boilers

4.10.1.1 Where steam is required for the main propelling engines, for auxiliary machinery for essential services, or for heating of heavy fuel oil and is generated by burning oil fuel under pressure, there are to be not less than two oil burning units, each unit comprising a pressure pump, suction and discharge filters and a heater. For auxiliary boilers, a single oil burning unit may be accepted, provided that alternative means, such as an exhaust gas boiler or composite boiler, are available for supplying steam for essential services.

4.10.1.2 In two unit installations, each unit is to be capable of supplying fuel for generating all the steam required for essential services. In installations of three or more units, the capacities and arrangements of the units are to be such that all the steam required for essential services can be maintained with any one unit out of action.

4.10.1.3 In systems where oil is fed to the burners by gravity, duplex filters are to be fitted in the supply pipeline to the burners and so arranged that one filter can be opened up when the other is in use.

4.10.1.4 Where steam is required to bring the boiler plant into operation, starting up oil fuel unit, including an auxiliary heater and hand pump, or other suitable starting up device, which does not require power from shore, is to be provided.

4.10.1.5 Where burners are provided with steam purging and/or atomizing connections, the arrangements are to be such that oil fuel cannot find its way into steam system in the event of valve leakage.

4.10.1.6 The burner arrangements are to be such that a burner cannot be withdrawn unless the oil fuel supply to that burner is shut off and that oil cannot be turned on unless the burner has been correctly coupled to the supply line.

4.10.1.7 A quick-closing master valve is to be fitted to the oil supply to each boiler manifold, suitably located so that the valve can be readily operated in an emergency, either directly or by means of remote control, having regard to the machinery arrangements and location of controls.

4.10.1.8 In the case of top-fired boilers, means are to be provided so that, in the event of flame failure, oil fuel supply to the burners is shut off automatically, and audible and visual warnings are given.

4.10.1.9 Provision is to be made, by suitable non-return arrangements, to prevent oil from spill systems being returned to the burners when oil supply to these burners has been shut off.

4.10.1.10 For alternatively fired furnaces of the boilers using exhaust gases and oil fuel, the exhaust gas inlet pipe is to be provided with an isolating device and interlocking arrangements whereby oil fuel can only be supplied to the burners when the isolating device is closed to the boiler.

4.10.2 For internal combustion engines

4.10.2.1 Filters are to be fitted in the supply lines to the main and auxiliary machinery. For non-redundant units for essential services, it must be possible to clean the filters without stopping the unit or reducing the supply of filtered oil to the unit.

For auxiliary engines one single oil fuel filter for each engine may be accepted.

4.10.2.2 Where an oil fuel booster pump is fitted, which is essential to the operation of the main engine(s), a standby pump is to be provided. The standby pump is to be connected ready for immediate use but where two or more main engines are fitted, each with its own pump, a complete spare pump may be accepted provided that it is readily accessible and can be easily installed.

4.10.2.3 Where pumps are provided for fuel valve cooling, the arrangements are to be as in 4.10.2.2.

4.10.2.4 In multi-engine installations which are supplied from the same fuel source, means of isolating the fuel supply and spill piping to individual engines, shall be provided. The means of isolation shall not affect the operation of the other engines and shall be operable from a position not rendered inaccessible by a fire on any of the engines.

4.10.3 Oil fired galleys

4.10.3.1 The fuel supply to the burners is to be controlled from a position which will always be accessible in the event of a fire occurring in the galley.

4.10.3.2 The galley is to be well ventilated.

4.10.4 Special requirements for low sulphur Oil fuel burning arrangements:

For ships intending to use Heavy Fuel Oil (HFO) or Marine Diesel Oil (MDO) in non-restricted areas and marine fuels with a sulphur content not exceeding 0,1 % m/m and minimum viscosity of 2 cSt in emission control areas, the oil fuel burning arrangements essential for the normal operation of propulsion machinery are to comply with the following:

4.10.4.1 In non-restricted areas, ships are provided with two (2) fuel oil pumps that can each supply the fuel primarily used by the ship (i.e. HFO or MDO) in the required capacity for normal operation of the propulsion machinery.

4.10.4.2 In emission control areas one of the following configurations are to be provided:

a) Fuel oil pumps as in 4.10.4.1, provided these are each suitable for marine fuels with a sulphur content not exceeding 0.1 % m/m and minimum viscosity of 2 cSt operation at the required capacity for normal operation of propulsion machinery, or,

b) When the fuel oil pumps in 4.10.4.1 are suitable to operate on marine fuels with a sulphur content not exceeding 0.1 % m/m and minimum viscosity of 2 cSt but one pump alone is not capable of delivering marine fuels with a sulphur content not exceeding 0.1 % m/m and minimum viscosity of 2 cSt at the required capacity, then both pumps may operate in parallel to achieve the required capacity for normal operation of propulsion machinery. In this case, one additional fuel oil pump is to be provided. The additional pump is to, when operating in parallel with one of the pumps in 4.10.4.1, be suitable for and capable of delivering marine fuels with a sulphur content not exceeding 0,1 % m/m and minimum viscosity of 2 cSt at the required capacity for normal operation of the propulsion machinery, or,

c) In addition to 4.10.4.1, two separate fuel oil pumps are provided, each capable of and suitable for supplying marine fuels with a sulphur content not exceeding 0,1 % m/m and minimum viscosity of 2 cSt at the required capacity for normal operation of propulsion machinery.

Notes:

1. If a marine distillate grade fuel with a different maximum sulphur content is specified by regulation for the area of operation of the ship (e.g., ECA, specific ports or local areas, etc.) then that maximum is to be applied.

2. In the case of vessels with class notation SYJ, requirement in Pt. 5, Ch. 22 for activating of alarm when pumps are automatically started is applicable regardless of the pump arrangement.

3. Where electrical power is required for the operation of propulsion machinery, the requirements are also applicable for machinery for power generation when such machinery is supplied by common fuel supply pumps.

4. The minimum viscosity of 2cSt specified above is the value corresponding to the standard reference temperature.

4.11 Remote stop of oil fuel pumps and fans

4.11.1 Emergency stop of power supply to the following pumps and fans is to be arranged from a central place outside the engine and boiler room (Also refer Ch.8, Cl. 2.15.2) and Pt.6, Ch.2, Sec.2:

- oil fuel transfer pump;

- oil fuel booster pump;
- nozzle cooling pumps when oil fuel is used as coolant;
- oil fuel purifiers;
- pumps for oil-burning installations;
- fans for forced draught to boilers;
- fans for ventilation of engine and boiler rooms.

Section 5

Steam Piping and Condensate Piping Systems

5.1 Expansion and drainage

5.1.1 In all steam piping systems, ample provision is to be made for expansion and contraction to take place without unduly straining the pipes.

5.1.2 The slope of the pipes and the number and position of the drain valves or cocks are to be such that water can be efficiently drained from any portion of the steam piping system, when the ship is on even keel and/or designed trim and is either upright or has a list of not more than 5 degrees.

5.1.3 Drain valves or cocks are to be readily accessible.

5.2 Steam pipes in way of holds, shaft and pipe tunnels

5.2.1 In general, steam pipes are not to be led through spaces which may be used for carrying cargo. But where it is impracticable to avoid steam pipes passing through cargo spaces, the pipes are to be efficiently insulated, secured and protected against mechanical damage. Plans for such arrangements are to be submitted for consideration.

5.2.2 Where the steam pipes pass through shaft tunnels and pipe tunnels, these are to be efficiently secured and insulated in such a way that the lagging surface temperature does not exceed 60°C.

5.3 Relief valves

5.3.1 Auxiliary steam lines not designed to withstand boiler pressure are to be fitted with relief valves, installed on the low pressure side, immediately after pressure reducing valve, having sufficient discharge capacity to protect the piping against excessive pressure.

5.4 Steam supply to auxiliaries

5.4.1 The steam supply to steering gear and essential auxiliaries is to be so arranged that it is not affected in the event of main steam supply to propulsion machinery or cargo oil pumps being shut off.

5.5 Steam for fire extinguishing in cargo holds

5.5.1 Where steam is used for fire extinguishing in cargo holds, provision is to be made to prevent damage to cargo by leakage of steam or drip. Details of proposed precautionary measures are to be submitted for approval.

5.6 Condensate pumps

5.6.1 Two or more extraction pumps are to be provided for dealing with the condensate from the main and auxiliary condensers, at least one of which is to be independently driven. Where one of the independent feed pumps is fitted with direct suctions from the condensers and a discharge to the feed tank, it may be accepted as an independently driven extraction pump.

5.6.2 Condensate pumps are to be provided with valves or cocks, interposed between the pumps and the suctions and the discharge pipes, so that any pump may be opened up for overhaul while the others continue in operation.

Section 6

Boiler Feed Piping Systems

6.1 Feed water piping

6.1.1 Two separate means of feed are to be provided for all main and auxiliary boilers, which are required for essential services, with the exception of boilers in which steam is generated exclusively by exhaust gases or steam, where one means of feed will be accepted provided an alternative steam supply is available.

IR6.1.1 Where a steam generating system consists of two or more adequately sized boilers, one independent feed water supply pipe to each boiler from two feed pumps is considered acceptable.

6.2 Feed pumps

6.2.1 Two or more feed pumps are to be provided of sufficient capacity to supply the boilers under full load conditions with any one pump out of action. At least one of these pumps is to be independently driven.

6.2.2 In multiple screw ships in which there is only one independently driven feed pump, each main engine is to be provided with a feed pump.

6.2.3 Where only one independent feed pump has been provided, a harbour feed pump or an injector is to be fitted to provide second means of feed to the boilers which are in use when the main engines are not working.

6.2.4 The harbour feed pump, as required by 6.2.3, may be used as general service pump, provided that it is not connected to tanks containing oil, or to tanks, cofferdams and bilges which may contain oily water.

6.3 Valves, cocks and fittings

6.3.1 Independent feed pumps, required for feeding the main boilers, are to be fitted with automatic regulators for controlling their output.

6.3.2 The valves on the suction pipes from hotwell or condenser and the feed drain tanks or filter are to be of the non-return type.

6.3.3 Feed pumps are to be provided with valves or cocks, interposed between the pumps and the suction and the discharge pipes, so that any pump may be opened up for overhaul while the others continue in operation.

6.4 Fresh-water connections

6.4.1 Feed pumps for water-tube boilers are to have fresh-water connections only.

6.5 Feed water tanks

6.5.1 All ships fitted with boilers are to be provided with storage space for reserve feed water. Capacity of these tanks is to be at least twice the hourly evaporation rate of the boilers.

6.5.2 Feed water tanks are to be separated from oil tanks by cofferdam.

6.6 Evaporators

6.6.1 For main boilers, one or more evaporators, of adequate capacity, are to be provided.

Section 7

Engine Cooling Water Systems

7.1 General

7.1.1 Centrifugal cooling water pumps are to be installed as low as possible in the ship.

7.2 Cooling water main supply

7.2.1 Provision is to be made for an adequate supply of cooling water to the main propelling machinery and essential auxiliary engines, also to lubricating oil and fresh water coolers and air coolers for electric propelling machinery, where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

7.3 Cooling water standby supply

7.3.1 Provision is also to be made for a separate supply of cooling water from a suitable independent pump of adequate capacity.

7.3.2 The following arrangements are acceptable, depending on the purpose for which the cooling water is intended:

a) Where only one main engine is fitted, the standby pump is to be connected ready for immediate use;

b) Where more than one main engine is fitted, each with its own pump, a complete spare pump of each type may be accepted;

c) Where a sea inlet scoop arrangement is fitted, and there is only one independent condenser circulating pump, a further pump, or a connection to the largest available pump suitable for circulation duties, is to be fitted to provide the second means of circulation when the ship is maneuvering. The pump is to be connected ready for immediate use;

d) Where fresh water cooling is employed for main/or auxiliary engines, a standby means of cooling need not be fitted if there are suitable emergency connections from a salt water system;

e) Where each auxiliary is fitted with a cooling water pump, standby means of cooling need not be provided for auxiliaries. Where, however a group of auxiliaries is supplied with cooling water from a common system, a standby cooling water pump is to be provided for this system. This pump is to be connected ready for immediate use and may be a suitable general service pump.

7.3.3 When selecting a pump for standby purposes, consideration is to be given to the maximum pressure which it can develop if the overboard discharge valve is partly or fully closed and, when necessary, condenser doors, water boxes, etc. are to be protected by an approved device against inadvertent over pressure.

7.4 Relief valves on cooling water pumps

7.4.1 Where cooling water pumps can develop a pressure head greater than the design pressure of the system, they are to be provided with relief valves on the pump discharge to effectively limit the pump discharge pressure to the design pressure of the system.

7.5 Sea inlets for cooling water pumps

7.5.1 Sea-water cooling systems for main and auxiliary machinery are to be connected to at least two cooling water inlets, preferably on opposite sides of the ship.

7.5.2 Where sea water is used for the direct cooling of main engines and auxiliaries, the sea water suction pipes are to be provided with strainers which can be cleaned without interrupting the cooling water supply.

Section 8

Lubricating Oil Piping Systems

8.1 General

8.1.1 The lubricating systems are to be so arranged that they will remain efficient with the ship inclined from the normal to any angle up to 15° transversely and when pitching 10° longitudinally and when rolling up to 22.5° from the vertical.

8.1.2 Lubricating oil systems are to be entirely separated from other systems. This requirement, however, does not apply to hydraulic governing and maneuvering systems for main and auxiliary engines.

8.1.3 Lubricating oil tanks are to be separated from other tanks containing water, fuel oil or cargo oil, by means of cofferdams.

8.1.4 For fire protection requirements also refer Pt.6, Ch.2, 1.2.3.

8.2 Pumps

8.2.1 Where lubricating oil for the main engine(s) is circulated under pressure, a standby lubricating oil pump is to be provided where the following conditions apply:

a) The lubricating oil pump is independently driven and the total output of the main engine(s) exceeds 370 [kW];

b) One main engine with its own pump is fitted and the output of the engine exceeds 370 [kW];

c) More than one main engine each with its own lubricating oil pump is fitted and the output of each engine exceeds 370 [kW].

8.2.2 The standby pump is to be of sufficient capacity to maintain the supply of oil for normal conditions with any one pump out of action. The pump is to be fitted and connected ready for immediate use, except that where the conditions referred to in 8.2.1(c) apply, a complete spare pump may be accepted. In all cases satisfactory lubrication of the engines is to be ensured while starting and maneuvering.

8.2.3 Similar provisions to those of 8.2.1 and 8.2.2 are to be made where separate lubricating oil systems are employed for piston cooling, reduction gearing, oil operated couplings and controllable pitch propellers, unless approved alternative arrangements are provided. Where the oil glands for stern tubes are provided with oil circulating pump, and the continuous running of this pump is necessary during normal operation, then a standby pump for this purpose is to be provided.

8.2.4 Independently driven rotary type pumps are to be fitted with non- return valves on the discharge side of the pumps.

8.2.5 A relief valve in close circuit is to be fitted on the pump discharge if the pump is capable of developing a pressure exceeding the design pressure of the system, the relief valve is to effectively limit the pump discharge pressure to the design pressure of the system.

8.3 Control of pumps and alarms

8.3.1 The power supply, to all independently driven lubricating oil service pumps is to be capable of being stopped from a position outside the space which will always be accessible in the event of fire occurring in the compartment in which they are situated, as well as from the compartment itself.

8.3.2 All main and auxiliary engines and turbines intended for essential services are to be provided with means of indicating the lubricating oil pressure supply to them. Alarms for reduction in pressure of the lubricating oil supply are to be actuated from the outlet side of any restrictions such as filters, coolers etc. For main and auxiliary internal combustion engines, above 37 [kW] an alarm device with audible and visual signal for failure of lubricating system is to be provided.

8.4 Emergency supply for propulsion turbines and propulsion turbogenerators

8.4.1 A suitable emergency supply of lubricating oil is to be arranged to come automatically into use in the event of low oil pressure.

The emergency source of supply is to be independent of power from main switchboard.

8.4.2 The emergency supply may be obtained from a gravity tank containing sufficient oil to maintain adequate lubrication for not less than 6 minutes, and, in case of propulsion turbo-generators, until the unloaded turbine comes to rest from its maximum rated running speed.

8.5 Filters

8.5.1 In systems, where lubricating oil is circulated under pressure, provision is to be made for efficient filtration of the oil. For non-redundant units, for essential services, it must be possible to clean the filters without stopping the unit or reducing the supply of filtered oil to the units.

8.5.2 In the case of propulsion turbines and their gears, arrangements are to be made for lubricating oil to pass through magnetic strainers and fine filters.

8.6 Valves and cocks on lubricating oil tanks

8.6.1 The provisions of 4.4.4, 4.4.5 and 4.4.6 are also to apply to lubricating oil tanks except those having a capacity less than 500 litres, storage tanks on which valves are closed during the normal operation mode of the ship, or where it is determined that an unintended operation of a quick closing valve on the oil lubricating tank would endanger the safe operation of the main propulsion and essential auxiliary machinery.

8.6.2 Where an engine lubricating oil drain tank extends to the bottom shell plating in ships that are required to be provided with a double bottom, a shutoff valve is to be fitted in the drain pipe between the engine crank case and the double bottom lubricating oil tank. This valve is to be capable of being closed from an accessible position above the level of the lower platform (floor plates).

End of Chapter

Chapter 4

Prime Movers and Propulsion Shafting Systems

Contents

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to all ships but may be modified for ships classed for restricted services or for special services.

1.1.2 Prime movers of less than 100 [kW] capacity may be accepted based upon manufacturer's certificate provided the prime movers are of an approved type.

1.1.3 Attention is drawn to any relevant statutory requirements of the country in which the ship is to be registered.

1.1.4 Prime movers and power transmission systems not specified in this Chapter will be specially considered by IRS.

1.2 Materials

1.2.1 Materials intended for the main parts of the prime movers and power transmission systems are to be manufactured and tested in accordance with the requirements of Pt.2.

1.3 Turning gear

1.3.1 Arrangements are to be provided to turn the prime movers of main propulsion systems, reduction gears and auxiliary drives. Suitable interlocks are to be provided.

1.4 Power ratings

1.4.1 Where requirements to dimensions in this Chapter are based on power and revolutions per minute, the values to be applied are maximum continuous power measured on engine output shaft and corresponding revolutions per minute.

1.4.2 The maximum continuous power for which the engine is to be approved is defined in ISO 3046/I for oil engines and ISO 3977 for gas turbines.

1.4.3 For plants where overload is used frequently, the scantling criteria may have to be based on over load due to accumulated fatigue.

1.5 Overload capacity

1.5.1 Prime movers of electric generators are to be capable of developing 10 per cent overload for a short period of time (15 minutes). The overload power refers to the power of the generator set.

1.6 Certification of machinery

1.6.1 The certification of machinery is to be in accordance with requirements given in Chapter 1, Section 4 of this part.

1.7 Type approval program

1.7.1 Products that can be consistently manufactured to the same design and specification may be type approved in accordance with "IRS certification scheme for type approval of products".

1.7.2 For non mass-produced engines the requirements given in subsection 4.12 of this chapter are applicable for type approval.

1.7.3 For mass-produced machinery, "Type approval certification scheme for machinery manufactured by mass production system" is to be referred to.

Section 2

Steam Turbines

2.1 Scope

2.1.1 The requirements of this Section are applicable to steam turbines for main propulsion and to those for essential auxiliary services.

2.2 Plan and particulars

2.2.1 The following plans are to be submitted for consideration, together with particulars of materials, maximum shaft powers and revolutions per minute. The pressures and temperatures applicable at maximum shaft power and under the emergency conditions are to be stated or indicated on the plans.

- General technical specifications;
- General arrangement;
- Sections showing rotors, bearings and casings;
- Sections showing typical blades and blade fastenings;
- Integrated steam and drain piping;
- Foundation and fastening;
- Block diagram with functional description of control and monitoring system;
- Lubricating oil system;
- Operating instructions manual; and
- Test programmes.

If required, the following information is also to be submitted:

- Vibration calculation of rotors and/or blades;
- Performance characteristics with functional description;
- Specification of reliability and availability; and
- Analysis proving the specified reliability and availability.

2.2.2 Full particulars of the means proposed for emergency propulsion are to be submitted.

2.2.3 Where rotors and castings are of welded construction, details of the welded joints are also to be submitted for consideration.

2.3 Materials

2.3.1 In the selection of materials, consideration is to be given to their creep strength, corrosion resistance and scaling properties at working temperatures to ensure satisfactory performance and long life under service condition.

2.3.2 Grey cast iron is not to be used for temperatures exceeding 260°C.

2.3.3 Turbine rotors and discs are to be of forged steel. For carbon and carbon-manganese steel forgings, the specified minimum tensile strength is to be selected within the limits of 400 and 600 [N/mm^2]. For alloy steel rotor forgings, the specified minimum tensile strength is to be selected within the limits of 500 and 800 [N/mm^2]. For discs and other alloy steel forgings, the specified minimum tensile strength is to be selected within the limits of 500 and 1000 [N/mm^2].

2.3.4 For alloy steels, details of the proposed chemical composition, heat treatment and mechanical properties are to be submitted for approval.

2.3.5 When it is proposed to use material of higher tensile strength, full details are to be submitted for approval.

2.4 Design and construction

2.4.1 In the design and arrangement of turbine machinery, adequate provision is to be made for the relative thermal expansion of the various turbine parts, and special attention is to be given to minimizing casing and rotor distortion under all operating conditions.

2.4.2 Turbine bearings are to be so disposed and supported that lubrication is not adversely affected by heat flow from adjacent hot parts of the turbine. Effective means are to be provided for intercepting oil leakage and preventing oil from reaching high temperature glands and casings and steam pipes pockets are to be sufficiently large to prevent excessive accumulation and leakage of oil.

2.4.3 The design analysis, if required, is to include a full vibration analysis with measurements as necessary, covering vibration of the rotor as well as blade vibrations.

2.4.4 Turbine rotors, cylinders and associated components fabricated by means of welding will be considered for acceptance if constructed by firms whose works are properly equipped to undertake welding to equivalent standards, for rotors and cylinders respectively, to those required by the Rules for Class 1 welded pressure vessels, See Ch.10.

2.4.5 Before work is commenced, manufacturers are to submit for consideration details of proposed welding procedures and their proposals for routine examination of joints by non-destructive means.

2.4.6 Where it is proposed to construct rotors from two or more forged components joined by welding, full details of the chemical composition, mechanical properties and heat treatment of the materials, together with particulars of the welding consumables, an outline of the welding procedure, method of fabrication and heat treatment, are to be submitted for consideration.

2.4.7 Joints in rotors and major joints in cylinders are to be designed as full-strength welds and for complete fusion of the joint.

2.4.8 Adequate preheating is to be employed for mild steel cylinders and components and where the metal thickness exceeds 44 [mm], and for all low alloy steel cylinders and components and for any part where necessitated by joint restraint.

2.4.9 Stress relief heat treatment is to be applied to all cylinders and associated components on completion of the welding of all joints and attached structures. For details of stress relief procedures, temperature and duration, See Ch.10.

2.4.10 Surveyors are to be satisfied that the desired quality of welding is attainable with the proposed welding equipment and procedure, and for this purpose test specimens representative of the welded joints are to be provided for radiographic examination and mechanical tests.

2.4.11 Smooth fillets are to be provided at abrupt changes of section of rotors, spindles, discs, blade roots and tensions. The rivet holes in blade shrouds are to be rounded and radiused on top and bottom surfaces, and tenons are to be radiused at their junction with blade tips. Balancing holes in discs are to be well rounded and polished.

2.4.12 Surveyors are to be satisfied as to the workmanship and riveting of blades to shroud bands, and that the blade tenons are free from cracks, particularly with high strength blade material. Test samples are to be sectioned and examined, and pull-off tests made if considered necessary by Surveyors.

2.4.13 Main turbine rotor discs fitted by shrinking are to be secured with keys, dowels or other approved means.

2.5 Vibration

2.5.1 Care is to be taken in the design and manufacture of turbine rotors, rotor discs and blades to ensure freedom from undue vibration within the operating speed range. Consideration of blade vibration should include the effect of centrifugal force, blade root fixing, metal temperature and disc flexibility where appropriate.

2.6 External influences

2.6.1 Pipes and ducts connected to turbine casings are to be so designed that no excessive thrust loads or moments are applied by them to the turbines. Grating and any fittings in way of sliding feet or flexible-plate supports are to be so arranged that casing expansion is not restricted. Where main turbine seatings incorporate a tank structure, consideration is to be given to the temperature variation of the tanks in service to ensure that turbine alignment will not be adversely affected.

2.7 Steam supply and water system

2.7.1 In the arrangement of the gland sealing system, the pipes are to be made self-draining and every precaution is to be taken against the possibility of condensed steam entering the glands and turbines. The steam supply to the gland sealing system is to be fitted with an effective drain trap. In the air ejector re-circulating water system, the connection to the condenser is to be so located that water cannot impinge on the L.P. rotor or casing.

2.8 Turning gear

2.8.1 The turning gear for all propulsion turbines is to be power-driven and if electric, is to be continuously rated.

2.9 Safety arrangement

2.9.1 Overspeed protective devices

a) An overspeed protective device is to be provided for main and auxiliary turbines to shut off the steam automatically and prevent the maximum designed speed being exceeded by more than 15 per cent.

b) Where two or more turbines of a compound main turbine installation are separately coupled to the same main gear wheel, and one over-speed protective device is provided, this is to be fitted to the L.P. ahead turbine. Hand trip gear for shutting off the steam in an emergency is to be provided at the maneuvering platform.

c) Where exhaust steam from auxiliary systems is led to the main turbine, activation of the over-speed protective device is to cut off this steam supply to the main turbine.

2.9.2 Speed governors

a) Where a turbine installation incorporates a reverse gear, electric transmission or reversible propeller, a speed governor in addition to, or in combination with, the overspeed protective device is to be fitted, and is to be capable of controlling the speed of the unloaded turbine without bringing the overspeed protective device into action.

b) Auxiliary turbines intended for driving electric generators are to be fitted with speed governors which, with fixed setting, are to control the speed within 10 per cent momentary variation and five per cent permanent variation when full load is suddenly taken off or put on. The permanent speed variations of alternating current machines intended for parallel operations are to equal within a tolerance of $\pm$ 0.5 per cent.

2.9.3 Low vacuum and over pressure protective device

a) Sentinel relief valves are to be provided at the exhaust ends of all turbines, to provide a warning to personnel of allowable pressure being exceeded. The valve discharge outlets are to be visible and suitably guarded if necessary to avoid injury to personnel. Where a low vacuum cut-out device is provided, the sentinel relief valve at the L.P. exhaust may be omitted.

b) Sentinel relief valves are to be provided at the exhaust ends of all auxiliary turbines and the valve discharge outlets are to be visible and suitably guarded if necessary. Low vacuum or over pressure cut-out devices, as appropriate, are also to be provided for auxiliary turbines not installed with their own condensers.

c) When for auxiliary turbines, the inlet steam pressure exceeds the pressure for which the exhaust casing and associated piping up to exhaust valve are designed, means to relieve the pressure are to be provided.

2.10 Bled steam connections

2.10.1 Non-return or other means, which will prevent steam and water returning to the turbines, are to be fitted in bled steam connections.

2.11 Steam strainers

2.11.1 Efficient steam strainers are to be provided close to the inlets to ahead and astern high pressure turbines, or alternatively at the inlets to the maneuvering valves.

2.12 Emergency arrangements

2.12.1 Lubricating oil failure

a) Arrangements are to be made for the steam to the ahead propulsion turbines to be automatically shut off in the event of failure of the lubricating oil pressure; however, steam is to be made available at the astern turbine for braking purposes in such an emergency.

b) Auxiliary turbine arrangements are to be such that steam supply is automatically shut off in the event of failure of the lubricating oil pressure.

c) Main turbines are to be provided with a satisfactory emergency supply of lubricating oil which will come into use automatically in case of lubricating oil pressure falling below a predetermined value. The emergency supply may be obtained from a gravity tank containing sufficient oil to maintain adequate lubrication until the turbine is brought to rest or by equivalent means. If emergency pumps are used these are to be so arranged that their operation is not affected by failure of the power supply. Suitable arrangements for cooling the bearings after stopping may also be required.

2.12.2 Single screw ships

a) In single screw ships fitted with cross compound steam turbine installations in which two or more turbines are separately coupled to the same main gear wheel, the arrangements are to be such as to enable safe navigation, when the steam supply to any one of the turbines is required to be isolated. For this emergency operation purpose, the steam may be led direct to the L.P. turbine and either the H.P. or I.P. turbine can exhaust direct to the condenser. Adequate arrangements and controls are to be provided for these operating conditions to ensure that the pressure and temperature of the steam will not exceed those which the turbines and condenser can safely withstand.

b) The necessary pipes and valves for these arrangements are to be readily available and properly marked. A fit up test of all combinations of pipes and valves is to be performed prior to the first sea trials.

c) The permissible power/speeds when operating without one of the turbines (all combinations) is to be specified and information provided on board.

d) The operation of the turbines under emergency conditions is to be assessed for the potential influence on shaft alignment and gear teeth loading conditions.

2.12.3 Single main boiler

a) Ships intended for unrestricted service, fitted with steam turbines and having a single main boiler, are to be provided with means to ensure emergency propulsion in the event of failure of the main boiler.

2.13 Tests and equipment

2.13.1 Stability testing of turbine rotors

a) All solid forged H.P. turbine rotors intended for main propulsion service where the inlet steam temperature exceeds 400°C are to be subjected to at least one thermal stability test. This requirement is also applicable to rotors constructed from two or more forged components joined by welding. The test may be carried out at the forge or turbine builders' works (a) after heat treatment and rough machining of the forging or (b) after final machining, or (c) after final machining and blading of the rotor. The stabilizing test temperature is to be not less than 28°C above the maximum steam temperature to which the rotor will be exposed and not more than the tempering temperature of the rotor material.

b) Where main turbine rotors are subjected to thermal stability tests at both forge and turbine builders' works the foregoing requirements are applicable to both tests. It is not required that auxiliary turbine rotors be tested for thermal stability, but if such tests are carried out, the requirements for main turbine rotors will be generally applicable.

2.14 Balancing

2.14.1 All rotors as finished-bladed and complete with half-coupling are to be dynamically balanced to the Surveyor's satisfaction, in a machine of sensitivity appropriate to the size of rotor.

2.15 Hydraulic tests

2.15.1 Maneuvering valves are to be tested to twice the working pressure. The nozzle boxes of impulse turbines are to be tested to 1.5 times the working pressure.

2.15.2 The cylinders of all turbines are to be tested to 1.5 times the working pressure in the casing, or to 2.0 bar whichever is greater.

2.15.3 For test purposes, the cylinders may be subdivided with temporary diaphragms for distribution of test pressures.

2.15.4 Condensers are to be tested in the steam space to 1.0 bar. The water space is to be tested to the maximum pressure which the pump can develop at ship's full draught with the discharge valve closed plus 0.7 bar with a minimum test pressure of 2.0 bar. Where the operating conditions are not known, the test pressure is to be not less than 3.4 bar.

2.16 Indicators for movement

2.16.1 Indicators for determining the axial position of rotors relative to their casings, and for showing the longitudinal expansion of casings at the sliding feet, if fitted, are to be provided for main turbines. The latter indicators should be fitted at both sides and be readily visible.

2.17 Weardown gauges

2.17.1 Main and auxiliary turbines are to be provided with bridge weardown gauges for testing the alignment of the rotors.

Section 3

Gas Turbines

3.1 Scope

3.1.1 The requirements of this Section are applicable to gas turbines for main propulsion and to those for essential auxiliary services. These requirements do not apply to exhaust gas turbo-blowers.

3.1.2 The spare gear for gas turbines has not been indicated in view of the variation in turbine design and service conditions. In the circumstances, a list of proposed spare gear is to be submitted for consideration.

3.2 Plans and particulars

3.2.1 Following data is to be submitted:

- Rated power;
- Rated speed;
- Maximum turbine entry temperature at which rated power can be achieved;
- Mass and velocity of rotating elements;
- Balancing data;
- Type test schedule, measurements and data;
- Manufacturer’s shop test schedule.

3.2.2 The following plans are to be submitted for consideration together with particulars of materials.

- General technical specifications including effect of inlet temperature on power;
- General arrangement;
- Sectional assembly;
- Casings;
- Combustion chambers and heat exchangers;
- Gasifiers;
- Regenerators or recuperators;
- Rotors (turbine and compressor), including discs, blades, bearings couplings, and clutches;
- Sections showing blades, blade fastenings and sealings;
- Oil fuel and lubricating oil systems including controls and safety devices;
- Governor arrangements;
- Enclosure configurations (where applicable);
- Starting arrangements;
- Air intake and exhaust system;
- Control systems, safety systems and devices and associated failure mode and effect analysis;
- Details of proposed automatic safety devices to safeguard against hazardous conditions arising in the event of malfunctions in the gas turbine installation together with failure mode and effect analysis;

- Vibration monitoring systems; and

- All other critical systems such as fire fighting arrangements for enclosures, ventilation, lighting, smoke detector etc.

3.2.3 Where applicable, plans are to indicate the most onerous pressures and temperatures to which each component is subject.

3.2.4 Details are to be submitted, where applicable, of high temperature characteristics of the materials, including (at the working temperatures) the associated creep rate and rupture strength for the designed service life, fatigue strength, corrosion resistance and scaling properties. Particulars of heat treatment, including stress relief, where applicable, are to be submitted.

3.3 Materials

3.3.1 Rotors and discs are to be of forged steel. For carbon and carbon- manganese steel forgings, the specified minimum tensile strength is to be selected within the limits of 400 and 600 [N/mm^2]. For alloy steel rotor forgings, the specified minimum tensile strength is to be selected within the limits of 500 and 800 [N/mm^2]. For discs and other alloy steel forgings, the specified minimum tensile strength is to be selected within the limits of 500 to 1000 [N/mm^2].

3.3.2 For alloy steels, specifications giving the proposed chemical composition and heat treatment are to be submitted for approval.

3.3.3 When it is proposed to use a material of higher tensile strength, full details are to be submitted for approval.

3.4 Design and construction

3.4.1 All parts of turbines, compressors, etc., are to have clearances and fits consistent with adequate provision for the relative thermal expansion of the various components. Special attention is to be given to minimizing casing and rotor distortion under all operating conditions.

3.4.2 Turbine bearings are to be so disposed and supported that lubrication is not adversely affected by heat flow from adjacent hot parts. Effective means are to be provided for intercepting oil leakage and preventing oil from reaching high temperature glands and casings.

3.4.3 Design basis

a) Calculations of the steady stresses, including the effect of stress raisers, etc., in the turbine and compressor rotors and blading at the maximum speed and temperature in service, are to be submitted for consideration. Such calculations should indicate the designed service life and be accompanied, where possible, by test results substantiating the limiting criteria.

b) Details of calculations and tests to establish the service life of other stressed parts, including gearing (where applicable), bearings, seals, etc., are to be submitted. All calculations and tests should take account of all relevant environmental factors including particular type of service and fuels intended to be used.

3.5 Welded components

3.5.1 Components fabricated by means of welding will be considered for acceptance if constructed by firms whose works are properly equipped to undertake welding of the standards appropriate to the components according to the relevant requirements of Ch.10.

3.5.2 Before work is commenced, manufacturers are to submit for consideration details of proposed welding procedures and their proposals for routine examination of joints by non-destructive means.

3.5.3 Major joints are to be designed as full-strength welds and for complete fusion of the joint.

3.5.4 Stress relief treatment is to be applied to all cylinders, rotors and associated components on completion of the welding of all joints and attached structures. For details of stress relief procedure, temperature and duration, See Ch.10.

3.5.5 Surveyors are to be satisfied that the desired quality of welding is attainable with the proposed welding equipment and procedure, and for this purpose test specimens representative of the welded joints are to be provided for radiographic examination and mechanical tests as required for steam turbines.

3.6 Vibration

3.6.1 Care is to be taken in the design and manufacture of turbine and compressor rotors, rotor discs and rotor blades to ensure freedom from undue vibration within the operating speed range. Calculations of the critical speeds giving full details of the basic assumptions are to be submitted for consideration. Where critical speeds are found by calculation to occur within the operating speed range, vibration tests may be requested in order to verify the calculations.

3.7 Containment

3.7.1 Consideration should be given to the need for containment, with a view to minimizing and localizing damage, in the event of rotor blade failure.

3.8 Inlet and exhaust systems

3.8.1 The air-inlet system is to be designed to minimize the entrance of harmful foreign matter.

3.8.2 The arrangement of the turbine exhaust system is to be such as to prevent exhaust gases being drawn into the compressors.

3.9 Fuel and salt deposits

3.9.1 When it is intended to burn non-distillate fuels forming harmful deposits, adequate provision should be made for periodic removal of the deposits.

3.9.2 Means for preventing the accumulation of salt deposits in the compressors and turbines are to be provided.

3.9.3 Flow path cleaning or washing system is to be provided, where required by the gas turbine manufacturer. Provision is to be made for periodical cleaning / washing by inhibiting liquids, steam or any other cleaning medium. The details of the arrangements and the associated system are to be submitted for approval.

3.10 Indication of temperature

3.10.1 Means are to be provided for indicating the temperature of the power turbine exhaust gases.

3.11 External influences

3.11.1 Pipes and ducting connected to casings are to be so designed that no excessive thrust loads or moments are applied by them to the compressors and turbines.

3.11.2 Platform gratings and fittings in way of the supports are to be so arranged that casing expansion is not restricted.

3.11.3 Where main turbine seatings incorporating a tank structure are proposed, consideration is to be given to the temperature variation of the tank in service to ensure that turbine alignment will not be adversely affected.

3.11.4 Where the turbine is provided with an acoustic enclosure, this is to act as shield to prevent contamination of machinery spaces from external hazards and contain the heat emission from the gas generator. The enclosure is to be structurally sound and is to be a self-contained unit with arrangements for ventilation, lighting and noise attenuation. The drainage arrangements in the enclosure are to be provided to prevent build up of liquids. A self contained and independent fire fighting system is to be provided for such enclosure. One or more observation window/s is/are to be provided for visual inspection of critical components such as auxiliary gearbox and burner manifold.

3.12 Overhaul life

3.12.1 The overhaul schedule recommended by the manufacturer is to be submitted for consideration.

3.13 Safety arrangements

3.13.1 Overspeed protective devices

a) An overspeed protective device is to be provided for each shaft of main and auxiliary turbines to shut off the fuel automatically, near the burners, to prevent a dangerous overspeed condition of the shaft, except where it can be established that such a condition cannot arise.

b) The overspeed device should normally be set to operate when the speed of the line exceeds the rated maximum speed by 15 per cent.

3.13.2 Speed governors

a) Where a main propulsion installation incorporates a reverse gear, electric transmission or controllable (reversible) pitch propeller, a speed governor, independent of the overspeed protective device, is to be fitted and is to be capable of controlling the speed of the unloaded power turbine without bringing the overspeed protective device into action.

b) Where an auxiliary turbine is intended for driving an electric generator, a speed governor, independent of the overspeed protective device, is to be fitted which, with fixed setting, is to control the speed within 10 per cent momentary variation and 5 per cent permanent variation when full load is suddenly taken off or put on. The permanent speed variation of a.c. machines intended for parallel operations are to be equal within a tolerance of 0.5 per cent.

3.13.3 The following turbine services are to be provided with automatic temperature controls so as to maintain steady state conditions throughout the normal operating range of the main turbine:

- lubricating oil system;
- oil fuel supply (or automatic control of oil fuel viscosity as an alternative); and
- exhaust gas.

3.13.4 Alarms and automatic shutdown devices are to be provided in accordance with Table 3.13.1.

3.13.5 Hand trip gear for shutting off the fuel in an emergency is to be provided locally at the turbine control platform and where applicable, at the centralized control station.

3.13.6 All non-mobile gas turbines are to be provided with independent, self contained suitable foam or CO_2 or water mist fire fighting system with detection ability to give warning automatically at local and remote control positions when activated. This system is to be distinctly separate from the fire fighting arrangements in the machinery space. The arrangements together with calculations showing the capacities of the cylinders is to be submitted for approval.

3.13.7 Inlet and exhaust silencers are to be fitted to limit the sound power level at one meter from the gas turbine system to 110 dB for unmanned machinery spaces or to 90 dB for manned machinery spaces.

3.14 Starting arrangements

3.14.1 Means are to be provided, preferably automatic or interlocked, to clear all parts of the gas turbine of the accumulation of liquid fuel, or for purging gaseous fuel, before ignition commences on starting, or recommences after failure to start.

3.14.2 The starting arrangements can be pneumatic, hydraulic or electric. The starting air pipes system, safety fittings and number of starts are to comply with the requirements for oil engines as given in Section 4.11.

3.14.3 Starting devices are to be so arranged that firing operation is discontinued and main fuel valve is closed within pre-determined time in case of ignition failure.

Table 3.13.1 : List of alarms and shutdown

Monitoring parameter	Alarm	Shutdown
Turbines speed	High value	Yes
Lubricating oil pressure	Low value	Yes
Lubricating oil pressure of reduction gear	Low value	Yes
Differential pressure across lubricating oil filter	High value	
Lubricating oil temperature	High value	
Oil fuel supply pressure	Low value	
Oil fuel temperature	High value	
Cooling medium temperature	High value	
Bearing temperature	High value	
Flame and ignition failure	Activated	Yes
Automatic starting failure	Activated	
Vibration	High value	Yes
Axial displacement of rotor	High value	Yes
Exhaust gas temperature	High value	Yes
Vacuum pressure at the compressor inlet	High value	Yes
Loss of control system	Activated	

3.14.4 Where the gas turbine is arranged for air starting, the total air receiver capacity is to be sufficient to provide, without replenishment, not less than six consecutive starts. At least two air receivers of equal capacity are to be provided. For details of air receivers, see Chapter 5. For multi engine installations three consecutive starts per engine are required.

3.15 Tests

3.15.1 Balancing

a) The rotors as finished-bladed and complete with half-coupling are to be dynamically balanced to the Surveyor's satisfaction, in a machine of sensitivity appropriate to the size of rotor.

3.15.2 Hydraulic tests

a) All casings are to be tested to a hydraulic pressure equal to 1.5 times the highest pressure in the casing during normal operation or 1.5 times the pressure during starting, whichever is the higher. For test purposes if necessary, the casings may be subdivided with temporary diaphragms for distribution of test pressure.

b) Where hydraulic tests cannot be carried out, the manufacturers are to submit, for approval, alternative proposals for determining the soundness of the component.

c) Inter coolers and heat exchangers are to be tested to 1.5 times the maximum working pressure on each side separately.

3.16 Shop trials

3.16.1 Upon completion of fabrication and assembly, each gas turbine is to be subjected to a shop trial in accordance with the manufacturer’s test schedule, which is to be submitted for review before the trial. During the trial, the turbine is to be brought up to its over speed limit to enable testing of the overspeed protective device.

3.17 Electric starting

3.17.1 Where main turbines are fitted with electric starters, two batteries are to be fitted. Each battery is to be capable of starting the turbines when cold and the combined capacity is to be sufficient without recharging to provide the number of starts of the main turbines as required by 3.14.4.

3.17.2 Electric starting arrangements for auxiliary turbines are to have two separate batteries or be supplied by separate circuits from the main turbine batteries when such are provided. Where one of the auxiliary turbines only is fitted with an electric starter one battery will be acceptable.

3.17.3 The combined capacity of the batteries for starting the auxiliary turbines is to be sufficient for at least three starts for each turbine.

3.17.4 The requirements for battery installations are given in Pt.4, Ch.8.

3.18 Type testing of gas turbine

3.18.1 Type tests are to be carried out in accordance with the agreed test programme on a representative machine comprising gas generator and power turbine and are to be witnessed by IRS surveyor. It may be carried out at the manufacturer’s works or at any establishment having suitable facilities acceptable to IRS.

3.18.2 Where the gas turbine unit can be separated conveniently into a gas generator and a power turbine, the type test is to include an initial test of the gas generator to ascertain that the fuel consumption and gas horse power are within $\pm 2.5\%$ of design maximum conditions at rated speed.

3.18.3 After completion of the initial test of the gas generator, the gas generator and power turbine are to be assembled together and prepared for the gas turbine type test.

3.18.4 On the over speed test, a propulsion gas generator is to be run at not less than 10% in excess of gas generator speed corresponding to specified full power of the gas turbine engine for not less than 10 minutes continuously and the power turbine disconnected from the dynamometer is to be run at not less than 15% in excess of the maximum designed speed for not less than 10 minutes continuously.

3.18.5 Where it is impracticable to overspeed the complete installation, each rotor, completely bladed and with all relevant parts such as half-couplings, shall be overspeed tested individually at the appropriate speed.

3.18.6 During the type tests at specified full power the pressure and temperature of the gas at outlet from the gas generator is to be recorded and the gas mass flow is to be assessed from air flow and fuel flow measurements.

3.18.7 During the type tests the following features are to be demonstrated:

i) Freedom from air and gas leaks.
ii) Operation of starting arrangements.
iii) Effectiveness of interlocks, if fitted.
iv) Satisfactory lubricating oil and fuel oil system characteristics.
v) Wet and dry motoring.
vi Engine start following a failure to start.
vii) Operation of engine cleaning system.
viii) Reliability of operation at minimum idling speed.

3.18.8 Starting tests are to be carried out to determine:

i) Time to light from cold.
ii) Time to reach idling speed from cold.
iii) Time to reach full output from idling speed.
iv) That the required number of starts can be obtained from the specified starting air bottle capacity.
v) The minimum pressure to ensure a cold start is to be established.

- A cold start is defined as a start after 2 hours or more of natural cooling with the engine at rest.

- A warm start is defined as a start within 15 minutes of shutting down after the engine has been running for not less than two hours.

- An intentional failure to start is defined as the performance of a normal starting sequence with the ignition system deliberately rendered inoperative.

Note : i), ii), iii) and iv) are to be average of four readings.

Section 4

Oil Engines

4.1 Scope

4.1.1 The requirements of this Section apply to conventional type of internal combustion engines used as prime movers for main propulsion and for essential auxiliary machinery.

4.1.2 The approval of IC Engines is covered in detail in the IRS *Classification Note "Approval of I.C Engines"*. The document flow between the engine designer, IRS Plan Approval Centre, engine builder/ licensee and IRS Surveyors is indicated in the Classification Note. The Classification Note also covers the procedure to be followed for certification of engine components. The requirements with regard to design approval, type testing and certification of turbochargers and their matching on engines is also indicated in the Classification Note (Also refer Cl. 4.11.4).

4.2 Materials and material testing

4.2.1 Materials used for the construction of oil engines are to comply with the requirements of Pt.2 in so far as applicable. Other materials will be specially considered.

4.2.2 The specified minimum tensile strength of castings and forgings for crankshafts is to be selected within the following general limits:

a) Carbon and carbon-manganese steel castings 400 - 550 [N/mm^2];

b) Carbon and carbon manganese steel forgings (normalized and tempered) : 400 - 600 [N/mm^2];

c) Carbon and carbon-manganese steel forgings (quenched and tempered) : not exceeding 700 [N/mm^2];

d) Alloy steel castings : not exceeding 700 [N/mm^2];

e) Alloy steel-forgings : not exceeding 1000 [N/mm^2];

f) Spheroidal or nodular graphite iron castings: 370 - 800 [N/mm^2].

4.2.3 Where it is proposed to use alloy steel castings, forgings or iron castings for crankshafts, details of the chemical composition, heat treatment and mechanical properties are to be submitted for approval.

4.2.4 Documentation required to be submitted for certification of engine components including their materials are indicated in the IRS *Classification Note "Approval of I.C Engines"*.

4.3 Crankshaft design

4.3.1 Detailed analysis to prove the design of the crankshaft is to be submitted for consideration. Classification Notes on design of crankshafts may be followed in this regard. Manufacturers may also be required to submit detailed analysis for special design features, e.g. serrations in connecting rods and bearing caps.

4.4 Design and construction

4.4.1 The design and construction is to be such as to enable the oil engine to meet the general requirements with regard to environmental conditions, functional capability and reliability.

4.4.2 Cylinders, cylinder liners, cylinder covers, pistons and other parts subject to high temperature or pressure are to be of material suitable for the stress and temperature to which they are exposed.

4.4.3 The engine bedplate or crankcase is to be of rigid and oil-tight construction. The bedplate is to be provided with sufficient number of holding down bolts to effectively secure it to the engine seatings.

4.4.4 Transverse girders, cylinder blocks and columns, when of fabricated construction, are normally to be stress-relieved after welding.

4.4.5 Crankcases and their doors are to be of robust construction and the doors are to be securely fastened so that they will not be readily displaced by an explosion taking into account the installation of explosion relief valve as required by 4.6.

4.4.6 Piston rod glands, which are subjected to pressure from scavenging air, are to be of a design ensuring that air will not leak into the crankcase.

4.5 Crankcase ventilation

4.5.1 Ventilation of crankcase and any arrangement which could produce a flow of external air within the crankcase, is in general not permitted except for dual fuel engines where crankcase ventilation is to be provided in accordance with 4.13.1.3. If forced extraction of the gases from crankcase is provided (e.g. for smoke-detection purposes), the vacuum in the crankcase is not to exceed 25 [mm] of water column.

4.5.2 Crankcase ventilation pipes where provided are to be as small as practicable to minimize the in rush of air after crankcase explosion.

4.5.3 To avoid interconnection between crankcases and the possible spread of fire following an explosion, crankcase ventilation pipes and oil drain pipes for each engine are to be independent of each other.

4.6 Safety devices

4.6.1 For crankcase:

4.6.1.1 Crankcases are to be provided with light weight spring-loaded valves or other quick-acting and self closing devices, of an approved type, to relieve the crankcases of pressure in the event of an internal explosion and to prevent any inrush of air thereafter. The valves are to be designed to open at a pressure not greater than 0.2 bar.

4.6.1.2 The valve lids are to be made of ductile material capable of withstanding the shock of contact with stoppers at the full open position. The discharge from the valves is to be shielded by flame guard or flame trap to minimise the possibility of danger and damage arising from the emission of flame.

4.6.1.3 Crankcase explosion relief valves are to be type tested in a configuration that represents the installation arrangements that will be used on an engine, in accordance with IRS Classification Notes on “Guidance for Type Testing of Crankcase Explosion Relief Valves”.

4.6.1.4 Where crankcase relief valves are provided with arrangements for shielding emissions from the valve following an explosion, the valve is to be type tested to demonstrate that the shielding does not adversely affect the operational effectiveness of the valve.

4.6.1.5 Crankcase explosion relief valves are to be provided with a copy of manufacturer’s installation and maintenance manual that is specific to the size and type of valve being supplied for installation on a particular engine. The manual is to contain the following information:

- Description of valve with details of function and design limits.
- Copy of type test certificate.
- Installation instructions.
- Instructions for testing and renewal of any sealing arrangements.
- Actions required after a crankcase explosion.

4.6.1.6 A copy of the installation and maintenance manual required by 4.6.1.5 is to be provided on board ship.

4.6.1.7 Plans / documentation showing details and arrangements of crankcase explosion relief valves are to be submitted for approval, as indicated in the IRS *Classification Note "Approval of I.C Engines"*.

4.6.1.8 Valves are to be provided with suitable markings that include the following information:

- Name and address of manufacturer
- Designation and size
- Month / Year of manufacture
- Approved installation orientation.

4.6.1.9 In engines having cylinders not exceeding 200 [mm] bore and having a crankcase gross volume not exceeding 0.6 [m^3], relief valves may be omitted.

4.6.1.10 In engines having cylinders exceeding 200 [mm] bore, but not exceeding 250 [mm] bore, at least two relief valves are to be fitted, each valve is to be located at or near the ends of the crankcase. Where the engine has more than 8 crank throws an additional valve is to be fitted near the center of the engine.

4.6.1.11 Engines, with cylinder bores exceeding 250 [mm], but not exceeding 300 [mm], are to have at least one relief valve in way of each alternate crank throw, with a minimum of two relief valves.

4.6.1.12 In engines having cylinders exceeding 300 [mm] bore, at least one relief valve is to be fitted in way of each main crank throw.

4.6.1.13 Additional relief valves are to be fitted for separate spaces on the crankcase, such as gear or chain cases for camshaft or similar drives, when the gross volume of such spaces exceeds 0.6 [m^3].

4.6.1.14 The free area of each crankcase relief valve is not to be less than 45 [cm^2]. The combined free area of the relief valves fitted on the engine is not to be less than 115 [cm^2/m^3] of the crankcase volume.

The free area of the relief valve is the minimum flow area at any section through the valve, when the valve is fully open.

When calculating the gross volume of the crankcase, the volume of stationary parts within the crankcase may be deducted.

4.6.1.15 A warning notice is to be fitted in a prominent position, preferably on a crankcase door on each side of the engine, or alternatively at the engine room control location. This warning notice is to specify that whenever overheating is suspected in the crankcase, the crankcase doors or sight holes are not to be opened until a reasonable time has elapsed after stopping the engine, sufficient to permit adequate cooling within the crankcase.

4.6.1.16 Where crankcase oil mist detection arrangements are to be fitted to engines (as per Pt.4, Ch.7 and Pt.5, Ch.22) they are to be of a type approved by IRS and tested in accordance with Note 1) and comply with 4.6.1.17 to 4.6.1.28. Engine bearing temperature monitors or equivalent devices used as safety devices are to be type approved by IRS for such purposes.

Note 1) : Classification Notes – "Type approval of crankcase oil mist detection and alarm equipment".

4.6.1.17 The oil mist detection system and arrangements are to be installed in accordance with the manufacturer's and engine designer's instructions / recommendations. The following particulars are to be included in the instructions:

- Schematic layout of engine oil mist detection and alarm system showing location of engine crankcase sample points and piping or cable arrangements together with dimensions of the pipe to the detector.

- Evidence of study to justify the selected location of sample points and sample extraction rate (if applicable) in consideration of the crankcase arrangements and geometry and the predicted, crankcase atmosphere where oil mist can accumulate.

- The manufacturer's maintenance and test manual.

- Information relating to type or in-service testing of the engine with engine protection system test arrangements having approved types of oil mist detection equipment.

4.6.1.18 A copy of the oil mist detection equipment maintenance and test manual required by 4.6.1.17 is to be provided on board ship.

4.6.1.19 Oil mist detection and alarm information is to be capable of being read from a safe location away from the engine.

4.6.1.20 Each engine is to be provided with its own independent oil mist detection arrangement and a dedicated alarm.

4.6.1.21 Oil mist detection and alarm systems are to be capable of being tested on the test bed and onboard under engine at standstill and engine running at normal operating conditions in accordance with test procedures that are acceptable to IRS.

4.6.1.22 Alarms and shutdowns for the oil mist detection system are to be in accordance with Pt.5, Ch.22, Sec.3 and the system arrangements are to comply with Pt.5, Ch.22, Sec.2.

4.6.1.23 The oil mist detection arrangements are to provide an alarm indication in the event of a foreseeable functional failure in the equipment and installation arrangements.

4.6.1.24 The oil mist detection system is to provide an indication when any lenses fitted in the equipment and used in determination of the oil mist level have been partially obscured to a degree that will affect the reliability of the information and alarm indication.

4.6.1.25 Where oil mist detection equipment includes the use of programmable electronic systems, the arrangements are to be in accordance with the rule requirements for such systems.

4.6.1.26 Plans of showing details and arrangements of oil mist detection and alarm arrangements are to be submitted for approval in accordance with Pt.4, Ch.7.

4.6.1.27 The equipment together with detectors is to be tested when installed on the test bed and on board ship to demonstrate that the detection and alarm system functionally operates. The testing arrangements are to be to the satisfaction of IRS.

4.6.1.28 Where sequential oil mist detection arrangements are provided the sampling frequency and time is to be as short as reasonably practicable.

4.6.1.29 Where alternative methods are provided for the prevention of the build-up of oil mist that may lead to a potentially explosive condition within the crankcase details are to be submitted for consideration. The following information is to be included in the details:

- Engine particulars – type, power, speed, stroke, bore and crankcase volume.

- Details of arrangements to prevent the build up of potentially explosive conditions within the crankcase, e.g. bearing temperature monitoring, oil splash temperature, crankcase pressure monitoring, recirculation arrangements.

- Evidence to demonstrate that the arrangements are effective in preventing the build up of potentially explosive conditions together with details of in-service experience.

- Operating instructions and the maintenance and test instructions.

4.6.1.30 Where it is proposed to use the introduction of inert gas into crankcase to minimize a potential crankcase explosion, details of the arrangements are to be submitted to IRS for consideration.

4.6.2 Scavenge spaces:

4.6.2.1 Scavenge spaces in open connection to the cylinders are to be fitted with relief valves. The valves are to open quickly in case of an explosion.

4.6.2.2 For crosshead type engines, scavenge spaces in open connection to the cylinders are to be provided with an approved fire extinguishing system, which is to be entirely separate from the fire extinguishing system of the engine room.

4.6.3 Cylinders:

4.6.3.1 Cylinder relief valves are to be fitted to engines having cylinders over 230 [mm] bore. The valves are to open at a pressure not exceeding 40 per cent above the designed maximum pressure and are to discharge where no damage can occur. Consideration will be given to any other alternative relief arrangement.

4.6.3.2 In the case of auxiliary engines, consideration will be given to the replacement of the relief valve by an efficient warning device of over pressure in the cylinders.

4.6.4 Lubrication system:

4.6.4.1 The lubricating oil drain pipes from the engine sump to drain tank are to be taken down as low as possible, to ensure that their outlet ends are submerged at all times. Where two or more engines are installed, vent pipes, if fitted, and lubricating oil drain pipes are to be installed independently of each other to prevent intercommunication between crankcases.

4.6.5 Fuel systems:

4.6.5.1 All external high-pressure fuel delivery lines between the high-pressure fuel pumps and fuel injectors are to be protected with a jacketed piping system capable of containing fuel from a high-pressure line failure. A jacketed pipe incorporates an outer pipe into which the high-pressure fuel pipe is placed, forming a permanent assembly. The jacketed piping system is to include means for collection of leakages and arrangements provided for an alarm to be given of a fuel line failure. However, this requirement need not be applied for engines intended to be fitted on board non-passenger vessels of less than 500 GT.

4.6.5.2 Components of a diesel engine fuel system is to be designed considering the maximum peak pressure which will be experienced in service, including any high pressure pulses which are generated and transmitted back into the fuel supply and spill lines by the action of fuel injection pumps. Connections within the fuel supply and spill lines are to be constructed having regard to their ability to prevent pressurized oil fuel leaks while in service and after maintenance.

4.6.6 Starting air:

4.6.6.1 In order to protect air main against explosion arising from improper functioning of starting valves, the following are to be fitted:

a) an isolating non-return valve or equivalent at the starting air supply connection to each engine;

b) a bursting disc or flame arrestor in way of the starting valve of each cylinder for direct reversing engines having a main starting manifold or at the supply inlet to the starting air manifold for non-reversing engines.

4.6.6.2 Bursting disc or flame arrestor may be omitted for engines having a bore not exceeding 230 [mm], or where the power of the engine is less than 1100 [kW].

4.6.7 Overspeed protective devices:

4.6.7.1 Each main engine developing 220 [kW] or over, which can be declutched or which drives a controllable pitch propeller, also each auxiliary engine developing 220 [kW] and over for driving an electric generator, is to be fitted with an approved overspeed protective device.

4.6.7.2 The overspeed protective device, including its driving mechanism is to be independent of the governor required by 4.7 and is to be so adjusted that the speed does not exceed that for which the engine and its driven machinery are to be classed by more than 20 per cent for main engines and 15 per cent for auxiliary engines.

4.7 Governing

4.7.1 For main propulsion engines:

An efficient governor is to be fitted to each main engine and so adjusted that the speed of the engine does not exceed that for which the engine is to be classed by more than 15 per cent.

When electronic speed governors of main engines form part of a remote control system, they are to comply with the following:

a) if lack of power to the governor may cause major and sudden changes in the preset speed and direction of the thrust of the propeller, back up power supply is to be provided;

b) local control of engines is always to be possible;

c) electronic speed governor and its actuators are to be type tested as per *IRS Classification Notes "Type Approval of Electrical Equipment used for Control, Monitoring, Alarm and Protection Systems for use in Ships; and*

d) Also refer requirements of *IRS Classification Notes "Approval of I.C. Engines".*

4.7.2 For auxiliary engines:

Governors on diesel engines driving main or emergency electric generators are to be capable of automatically maintaining the speeds within following limits:

a) Momentary variations of 10 per cent of the maximum rated speed when the rated load of the generator is suddenly thrown off;

b) Momentary variations of 10 per cent of the maximum rated speed when 50 per cent of the rated load is suddenly thrown on followed by the remaining 50 per cent load after an interval sufficient to restore the speed to steady state. Steady state conditions should be achieved in not more than 5 seconds;

Note : Steady state conditions are those at which the envelope of speed variation does to exceed +1% of the declared speed at the new power.

c) At all loads between no load and rated load the permanent speed variation is not to be more than 5 per cent of the maximum rated speed;

d) For generating sets operating in parallel, the governing characteristics of the engine are to be such that within the limits of 20 per cent and 100 per cent of total load, the load on any generating set does not normally differ from its proportionate share of the total load by more than

i) 15 per cent of the rated output of the largest machine; or

ii) 25 per cent of the rated output of the individual machine in question, whichever is less;

e) For generating sets intended to operate in parallel, it is to be possible to adjust the governor so that the load is kept within 5 per cent of the rated load at normal frequency;

f) For alternating current installations, the permanent speed variation of the machines intended for parallel operations are to be equal within a tolerance of ± 0.5 per cent.

g) Application of electrical load in more than 2 load steps (See Fig.4.7.2) can only be permitted on the condition that

- the design of the ship's electrical system enables the use of such generator sets

- such a provision is made in the design stage and same is approved while scrutinising the drawings

- the safety of the ship's electrical system in the event of parallel operation and failure of a generator is to be demonstrated at ship's trials.

4.7.3 Emergency generator sets must satisfy the above governor conditions even when :

a) their total consumer load is applied suddenly, or

b) their total consumer load is applied in steps, subject to following:

- the total load is supplied within 45 seconds since power failure of the main switchboard
- the maximum step load is declared and demonstrated
- the power distribution system is designed such that the declared maximum step loading is not exceeded

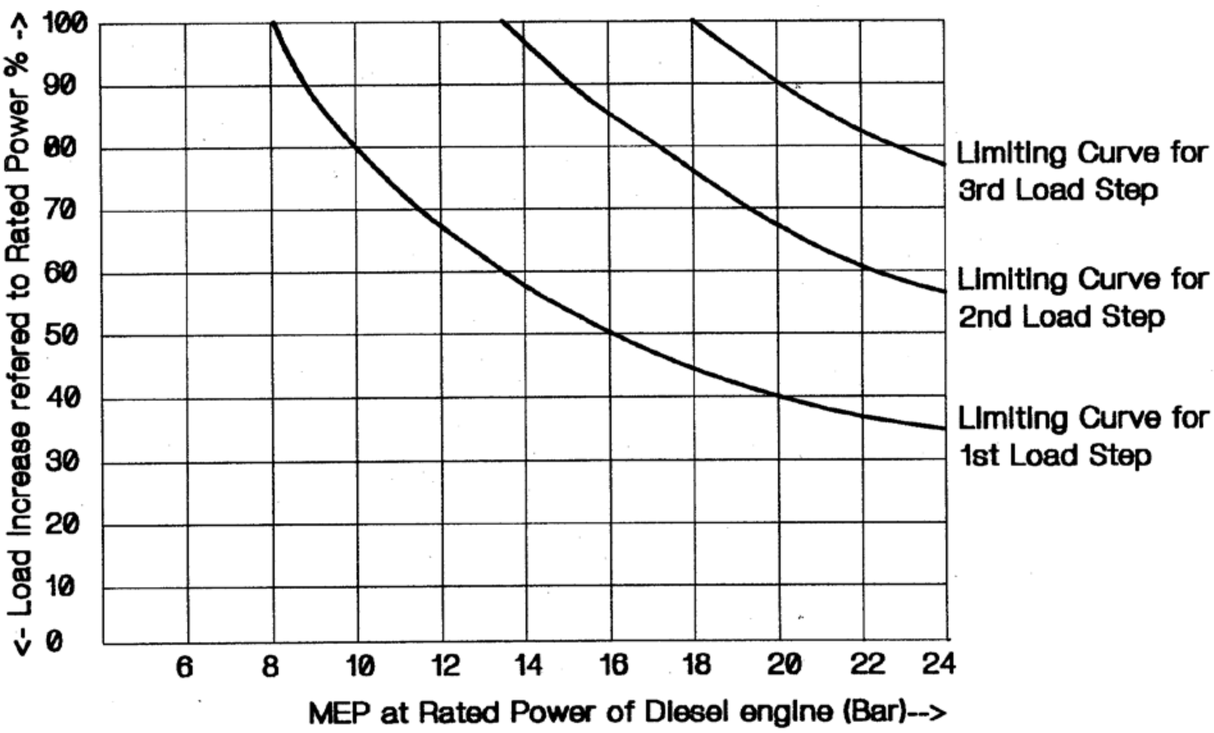


Fig.4.7.2 : Limiting curves for loading 4-stroke diesel engines step by step from no-load to rated power as function of the brake mean effective pressure

- the compliance of time delays and loading sequence with the above is to be demonstrated at the time of ship's trials.

4.8 Oil fuel, lubricating oil, cooling water and exhaust gas systems

4.8.1 Oil fuel, lubricating oil and cooling water piping systems are to comply with the requirements of Ch.3 in so far as these are applicable.

4.8.2 Exhaust pipes which are led overboard near the waterline are to be protected against the possibility of water finding its way inboard. Where the exhaust is cooled by water spray, the exhaust pipes are to be self-draining overboard.

4.8.3 Exhaust pipes of two or more engines are not to be connected together, but are to be led separately to the atmosphere unless arranged to prevent the return of gases to an idle engine.

4.9 Engine starting arrangements

4.9.1 First start arrangement:

4.9.1.1 Equipments for starting the main and auxiliary engines are to be provided so that the necessary initial charge of starting air or initial electric power can be developed on board ship without external aid. If for this purpose an emergency air compressor or electric generator is required, these units are to be power driven by hand starting oil engines or steam engines, except in the case of small installations where a hand operated compressor of approved capacity may be accepted. Alternatively, other devices of approved type may be accepted as a means of providing the initial start.

4.9.2 Compressed air starting systems:

4.9.2.1 Two or more starting and maneuvering air compressors of sufficient total capacity for the requirements of the main engines are to be fitted. At least one of the compressors is to be driven independent of the main propulsion unit and is to have a capacity not less than 50 per cent of the total required capacity. The total capacity of air compressors is to be sufficient to supply within one hour the quantity of air needed to satisfy the requirement of 4.9.2.9 by charging the receivers from atmospheric pressure. The main air compressors are to be of approximately the same size.

4.9.2.2 The compressors are to be so designed that the temperature of the air discharged to the starting air receivers will not substantially exceed 93°C in service. A small fusible plug or an alarm device operating at 121°C is to be provided on each compressor to give warning of excessive air temperature. The emergency air compressor need not comply with these requirements.

4.9.2.3 Each compressor is to be fitted with a safety valve so proportioned and adjusted that accumulation of pressure, with the outlet valve closed, will not exceed 10 per cent of the maximum working pressure.

4.9.2.4 The castings of the cooling water spaces are to be fitted with a safety valve or bursting disc so that ample relief will be provided in the event of the bursting of an air cooler tube.

4.9.2.5 Air compressor inlets are to be located in an atmosphere reasonably free from oil vapour or, alternatively, an air duct from outside the machinery space is to be led to the compressors.

4.9.2.6 The air discharge pipe from the compressors is to be led direct to the starting air receivers. Provision is to be made for intercepting and draining oil and water in the air discharge for which purpose a separator or filter is to be fitted in the discharge pipe between compressors and receivers.

4.9.2.7 The starting air pipe system from air receivers to main and auxiliary engines is to be entirely separate from the compressor discharge system. Stop valves on the air receivers are to permit slow opening to avoid sudden pressure rises in the piping system. Valve chests and fittings in the piping systems are to be of ductile material.

4.9.2.8 Drain valves for removing accumulations of oil and water are to be fitted on compressors, separators, filters and air receivers. In the case of any low-level pipelines, drain valves are to be fitted to suitably located drain pots or separators.

4.9.2.9 The total air receiver capacity is to be sufficient to provide, without replenishment, number of starts as per Table 4.9.1.

a) If starting system serves two or more of the above specified purposes, the capacity of the system is to be the sum of the capacity required.

b) At least two air receivers of about equal capacity are to be provided.

Table 4.9.1 : Number of starts of engines

Duty of engine	No. of starts
Propulsion engines – reversible	12 consecutive starts alternating between Ahead and Astern of each engine
Propulsion engines - non-reversible, connected to a controllable pitch propeller or other device enabling the start without opposite torque	6 starts for each engine
Engines for driving electric generators and emergency generators and engines for other purposes	3 starts for each engine

4.9.3 Electric starting

4.9.3.1 Where main engines are fitted with electric starters, two batteries are to be fitted. The arrangement is to be such that batteries cannot be connected in parallel.

4.9.3.2 Each battery is to be capable of starting the engines when in cold and ready to start conditions. The combined capacity is to be sufficient without recharging to provide within 30 minutes the number of starts of the main engines as required by 4.9.2.9.

4.9.3.3 The electric starting arrangements for auxiliary engines are to have two separate batteries or may be supplied by separate circuits from main engine batteries when such are provided. In case of a single auxiliary engine, only one battery is required.

4.9.3.4 The starting batteries are to be used for starting and engine's own monitoring purposes only. Provision is to be made to maintain continuously the stored energy at all times.

4.10 Type testing of oil engines

4.10.1 General

4.10.1.1 Requirements for Type Testing of Oil Engines are specified in *Classification Note "Approval of I.C Engines"*. The documentation required and document flow between the engine designer, IRS Plan Approval Centre, engine builder/ licensee and IRS Surveyors is also indicated in the Classification Note.

4.10.1.2 Upon finalization of the engine design for production of every new engine type intended for the installation on board ships, one engine is to be presented for type testing, as detailed in the IRS *Classification Note "Approval of I.C Engines"*.

4.11 Factory Acceptance Test

4.11.1 Safety Precautions

4.11.1.1 Before any test run is carried out, all relevant equipment for the safety of attending personnel is to be made available by the manufacturer / shipyard and is to be operational.

4.11.1.2 This applies especially to crankcase explosive conditions protection, but also to over-speed protection and any other shut down function.

4.11.1.3 The overspeed protective device is to be set to a value, which is not higher than the overspeed value that was demonstrated during the type test for that engine. This set point will be verified by the surveyor.

4.11.2 General

4.11.2.1 Before any official testing, the engines are to be run-in as prescribed by the engine manufacturer.

4.11.2.2 Adequate test bed facilities for loads as required in 4.11.3.7 are to be provided. All fluids used for testing purposes such as fuel, lubrication oil and cooling water are to be suitable for the purpose intended, e.g. they are to be clean, preheated if necessary and cause no harm to engine parts. This applies to all fluids used temporarily or repeatedly for testing purposes only.

4.11.2.3 The testing consists of workshop and shipboard (quay and sea trial) testing.

4.11.2.4 Engines are to be inspected for:

- Jacketing of high-pressure fuel oil lines including the system used for the detection of leakage.

- Screening of pipe connections in piping containing flammable liquids.

- Insulation of hot surfaces by taking random temperature readings that are to be compared with corresponding readings obtained during the type test. This is to be done while running at the rated power of engine. Use of contact thermometers may be accepted at the discretion of the attending Surveyor. If the insulation is modified subsequently to the Type Approval Test, IRS may request temperature measurements as required by *Classification Note "Approval of I.C Engines" 2.8.9.*

4.11.2.5 These inspections are normally to be made during the works trials by the manufacturer and the attending surveyor, but at the discretion of IRS parts of these inspections may be postponed to the shipboard testing.

4.11.3 Works trials

4.11.3.1 The purpose of the works trials is to verify design premises such as power, safety against fire, adherence to approved limits (e.g. maximum pressure), and functionality and to establish reference values or base lines for later reference in the operational phase.

4.11.3.2 The following environmental test conditions are to be recorded:

- Ambient air temperature
- Ambient air pressure
- Atmospheric humidity

4.11.3.3 For each required load point, the following parameters are normally to be recorded:

- Power and speed
- Fuel index (or equivalent reading)
- Maximum combustion pressures (only when the cylinder heads installed are designed for such measurement).
- Exhaust gas temperature before turbine and from each cylinder (to the extent that monitoring is required in *Classification Note "Approval of I.C Engines"* Sec 4 and Pt 5, Ch 22)
- Charge air temperature
- Charge air pressure
- Turbocharger speed (to the extent that monitoring is required in *Classification Note "Approval of I.C Engines" Sec 4*)

4.11.3.4 Calibration records for the instrumentation are, upon request, to be presented to the attending Surveyor.

4.11.3.5 For all stages at which the engine is to be tested, the pertaining operational values are to be measured and recorded by the engine manufacturer. All results are to be compiled in an acceptance protocol to be issued by the engine manufacturer. This also includes crankshaft deflections if considered necessary by the engine designer.

4.11.3.6 In each case, all measurements conducted at the various load points are to be carried out at steady state operating conditions. However, for all load points provision should be made for time needed by the Surveyor to carry out visual inspections. The readings for MCR, i.e. 100% power (rated maximum continuous power at corresponding rpm) are to be taken at least twice at an interval of normally 30 minutes.

4.11.3.7 Test loads for various engine applications are given in Tables below. In addition, the scope of the trials may be expanded depending on the engine application, service experience, or other relevant reasons.

Note:
Alternatives to the detailed tests may be agreed between the manufacturer and IRS when the overall scope of tests is found to be equivalent.

Table 4.11.3.7 (a) : Propulsion engines driving propeller or impeller only		
A)	100% power (MCR) at corresponding speed n_0 :	At least 60 [min]
B)	110% power at engine speed $1.032n_0$ Note: Only required once for each different engine/turbocharger configuration.	Records to be taken after 15 [min] or after steady conditions have been reached, whichever is shorter
C)	Approved intermittent overload (if applicable)	Testing for duration as agreed with the manufacturer
D)	90% (or normal continuous cruise power), 75%, 50%, and 25% power in accordance with the nominal propeller curve, the sequence to be selected by the engine manufacturer.	
E)	Reversing manoeuvres (if applicable)	
Note: *After running on the test bed, the fuel delivery system is to be so adjusted that overload power cannot be given in service, unless intermittent overload power is approved by IRS. In that case, the fuel delivery system is to be blocked to that power.*		

Table 4.11.3.7 (b) : Engines driving generators for electric propulsion and Engine driving generators for auxiliary purposes		
A)	100% power (MCR) at corresponding speed n_0 :	At least 60 [min]
B)	110% power at engine speed n_0	15 [min] - after having reached steady conditions
C)	Governor tests for compliance with 4.11.3.1 to 4.11.3.6 are to be carried out.	
D)	75%, 50%, and 25% power and idle, the sequence to be selected by the engine manufacturer.	
Note: *After running on the test bed, the fuel delivery system is to be adjusted so that full power plus a 10% margin for transient regulation can be given in service after installation onboard.* *The transient overload capability is required so that the required transient governing characteristics are achieved also at 100% loading of the engine, and also so that the protection system utilised in the electric distribution system can be activated before the engine stalls.*		

Table 4.11.3.7 (c) : Propulsion engines also driving power take off (PTO) generator		
A)	100% power (MCR) at corresponding speed n_0 :	At least 60 [min]
B)	110% power at engine speed n_0	15 [min] - after having reached steady conditions
C)	Approved intermittent overload (if applicable)	Testing for duration as agreed with the manufacturer.
D)	90% (or normal continuous cruise power), 75%, 50% and 25% power in accordance with the nominal propeller curve or at constant speed n_0, the sequence to be selected by the engine manufacturer.	
Note: *After running on the test bed, the fuel delivery system is to be adjusted so that full power plus a margin for transient regulation can be given in service after installation onboard. The transient overload capability is required so that the electrical protection of downstream system components is activated before the engine stalls. This margin may be 10% of the engine power but at least 10% of the PTO power.*		

Table 4.11.3.7 (d) : Engines driving auxiliaries

A)	100% power (MCR) at corresponding speed n_0 :	At least 30 [min]
B)	110% power at engine speed n_0	15 [min] - after having reached steady conditions
C)	Approved intermittent overload (if applicable)	Testing for duration as agreed with the manufacturer.
D)	For variable speed engines, 75%, 50% and 25% power in accordance with the nominal power consumption curve, the sequence to be selected by the engine manufacturer.	

Note:
After running on the test bed, the fuel delivery system is normally to be so adjusted that overload power cannot be delivered in service, unless intermittent overload power is approved. In that case, the fuel delivery system is to be blocked to that power.

4.11.4 Turbocharger matching with engine

4.11.4.1 Compressor chart

.1 Turbochargers are to have a compressor characteristic that allows the engine, for which it is intended, to operate without surging during all operating conditions and also after extended periods in operation.

.2 For abnormal, but permissible, operation conditions, such as misfiring and sudden load reduction, no continuous surging is to occur.

.3 In this section, *surging* and *continuous surging* are defined as follows:

Surging means the phenomenon, which results in a high pitch vibration of an audible level or explosion-like noise from the scavenger area of the engine.

Continuous surging means that surging happens repeatedly and not only once.

4.11.4.2 Surge margin verification

.1 Category C turbochargers used on propulsion engines are to be checked for surge margins during the engine workshop testing as specified below. These tests may be waived if successfully tested earlier on an identical configuration of engine and turbocharger (including same nozzle rings).

.2 For 4 stroke engines, following are to be performed without indication of surging:

- With maximum continuous power and speed (=100%), the speed is to be reduced with constant torque (fuel index) down to 90% power.
- With 50% power at 80% speed (= propeller characteristic for fixed pitch), the speed is to be reduced to 72% while keeping constant torque (fuel index).

.3 For 2 stroke engines, the surge margin is to be demonstrated by at least one of the following methods:

- The engine working characteristic established at workshop testing of the engine is to be plotted into the compressor chart of the turbocharger (established in a test rig). There is to be at least 10% surge margin in the full load range, i.e. working flow is to be 10% above the theoretical (mass) flow at surge limit (at no pressure fluctuations).
- Sudden fuel cut-off to at least one cylinder is not to result in continuous surging and the turbocharger is to be stabilised at the new load within 20 seconds. For applications with more than one turbocharger the fuel is to be cut-off to the cylinders closest upstream to each turbocharger. This test is to be performed at two different engine loads:
    - The maximum power permitted for one cylinder misfiring.
    - The engine load corresponding to a charge air pressure of about 0.6 [bar] (but without auxiliary blowers running).

- No continuous surging and the turbocharger is to be stabilised at the new load within 20 seconds when the power is abruptly reduced from 100% to 50% of the maximum continuous power.

4.11.5 Integration tests

4.11.5.1 For electronically controlled engines, integration tests are to be made to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes and the tests considered as a system are to be carried out at the works. If such tests are technically unfeasible at the works, however, these tests may be conducted during sea trial. The scope of these tests is to be agreed with IRS for selected cases based on the FMEA required in *Classification Note "Approval of I.C Engines" Sec 1.*

4.11.6 Component inspections

4.11.6.1 Random checks of components will be carried out by the attending surveyor.

4.12 Shipboard trials

4.12.1 Safety Precautions

4.12.1.1 Refer to 4.11.1

4.12.2 Objectives

4.12.2.1 The purpose of the shipboard testing is to verify compatibility with power transmission and driven machinery in the system, control systems and auxiliary systems necessary for the engine and integration of engine / shipboard control systems, as well as other items that had not been dealt with in the FAT (Factory Acceptance Testing).

4.12.3 Starting capacity

4.12.3.1 Starting manoeuvres are to be carried out in order to verify that the capacity of the starting media satisfies the required number of start attempts.

4.12.4 Monitoring and alarm system

4.12.4.1 The monitoring and alarm systems are to be checked to the full extent for all engines, except items already verified during the works trials.

4.12.5 Test loads

4.12.5.1 Test loads for various engine applications are given in tables below. In addition, the scope of the trials may be expanded depending on the engine application, service experience, or other relevant reasons.

4.12.5.2 The suitability of the engine to operate on fuels intended for use is to be demonstrated.

Note:
Tests other than those listed below may be required by statutory instruments (e.g. EEDI verification).

Table 4.12.5.1 (a) : Propulsion engines driving fixed pitch propeller or impeller

A)	At rated engine speed n_0 :	At least 4 [Hrs]
B)	At engine speed $1.032n_0$ (if engine adjustment permits , see 4.11.3.7)	30 [min]
C)	At approved intermittent overload (if applicable)	Testing for duration as agreed with the manufacturer
D)	Minimum engine speed to be determined	
E)	The ability of reversible engines to be operated in reverse direction is to be demonstrated.	

Note:
During stopping tests according to Resolution MSC.137 (76), see 4.12.6.1 for additional requirements in the case of a barred speed range.

Table 4.12.5.1 (b) : Propulsion engines driving controllable fixed pitch propellers		
A)	At rated engine speed n_0 with a propeller pitch leading to rated engine power (or to the maximum achievable power if 100% cannot be reached):	At least 4 [Hrs]
B)	At approved intermittent overload (if applicable)	Testing for duration as agreed with the manufacturer
C)	With reverse pitch suitable for manoeuvring, see 4.12.6.1 for additional requirements in the case of a barred speed range.	

Table 4.12.5.1 (c) : Engine(s) driving generator(s) for electrical propulsion and/or main power supply		
A)	At 100% power (rated electrical power of generator):	At least 60 [Min]
B)	At 110% power (rated electrical power of generator):	At least 10 [Min]
	Note: *Each engine is to be tested 100% electrical power for at least 60 min and 110% of rated electrical power of the generator for at least 10 min. This may, if possible, be done during the electrical propulsion plant test, which is required to be tested with 100% propulsion power (i.e. total electric motor capacity for propulsion) by distributing the power on as few generators as possible. The duration of this test is to be sufficient to reach stable operating temperatures of all rotating machines or for at least 4 hours. When some of the gen. set(s) cannot be tested due to insufficient time during the propulsion system test mentioned above, those required tests are to be carried out separately.*	
C)	Demonstration of the generator prime movers' and governors' ability to handle load steps as described in 4.11.3.2 and 4.11.3.3.	

Table 4.12.5.1 (d) : Propulsion engines also driving power take off (PTO) generator		
A)	100% power (MCR) at corresponding speed n_0 :	At least 4 [Hrs]
B)	100% propeller branch power at engine speed n_0 (unless already covered in A):	2 [Hrs]
C)	100% PTO branch power at engine speed n_0:	At least 1 [Hr]

Table 4.12.5.1 (e) : Engines driving auxiliaries		
A)	100% power (MCR) at corresponding speed n_0 :	At least 30 [Min]
B)	Approved intermittent overload:	Testing for duration as approved

4.12.6 Torsional vibrations

4.12.6.1 Barred speed range

.1 Where a barred speed range (BSR) is required, passages through this BSR, both accelerating and decelerating, are to be demonstrated. The times taken are to be recorded and are to be equal to or below those times stipulated in the approved documentation, if any. This also includes when passing through the BSR in reverse rotational direction, especially during the stopping test.

Note: Applies both for manual and automatic passing-through systems.

.2 The ship's draft and speed during all these demonstrations is to be recorded. In the case of a controllable pitch propeller, the pitch is also to be recorded.

.3 The engine is to be checked for stable running (steady fuel index) at both upper and lower borders of the BSR. Steady fuel index means an oscillation range less than 5% of the effective stroke (idle to full index).

4.13 Dual fuel diesel engines

4.13.1 Control and safety systems for Dual Fuel Diesel (DFD) engines

4.13.1.1 Application

a) The following requirements are applicable to dual-fuel diesel engines utilising high pressure Methane gas (NG: Natural Gas) as fuel. These requirements are in addition to those given in Pt.4, Ch.4 for oil fired diesel engines and Pt.5, Ch.4, Sec.5, 16 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

4.13.1.2 Operation mode

a) DFD engines are to be of the dual-fuel type employing pilot fuel ignition and to be capable of immediate change-over to oil fuel only.

b) Oil fuel only is to be used when starting the engine.

c) Oil fuel only, in principle, is to be used when the operation of an engine is unstable and/or during manoeuvring and port operations.

d) In case of shut-off of the gas fuel supply, the engines are to be capable of continuous operation by oil fuel only.

4.13.1.3 Protection of crankcase

a) Crankcase relief valves are to be fitted in way of each crankthrow. The construction and operating pressure of the relief valves are to be determined considering explosions due to gas leaks.

b) If a trunk piston type engine is used as DFD engine, the crankcase is to be protected by the following measures:

i) Ventilation is to be provided to prevent the accumulation of leaked gas, the outlet for which is to be led to a safe location in the open space through flame arrester.

ii) Gas detecting or equivalent equipment. (It is recommended that means for automatic injection of inert gas are to be provided).

iii) Oil mist detector.

c) If a cross-head type engine is used as DFD, the crankcase is to be protected by oil mist detector or bearing temperature detector.

4.13.1.4 Protection for piston underside space of cross-head type engine

a) Gas detecting or equivalent equipment is to be provided for piston underside space of cross-head type engine.

4.13.1.5 Engine exhaust system

a) Explosion relief valves or other appropriate protection system against explosion are to be provided in the exhaust, scavenge and air inlet manifolds.

b) The exhaust gas pipes from DFD engines are not to be connected to the exhaust pipes of other engines or systems.

4.13.1.6 Starting air line

a) Starting air branch pipes to each cylinder are to be provided with effective flame arresters.

4.13.1.7 Combustion monitoring

a) A failure mode and effect analysis (FMEA) examining all possible faults affecting the combustion process is to be submitted for approval.

Details of required monitoring will be considered based on the outcome of the analysis. The following table may serve as guidance:

Faulty condition	Alarm	Automatic shut-off of the interlocked valves*
Function of gas fuel injection valves and pilot oil fuel injection valves	X	X
Exhaust gas temperature at each cylinder outlet and deviation from average	X	X
Cylinder pressure or ignition failure of each cylinder	X	X
* It is recommended that the gas master valve is also closed.		

4.13.1.8 Gas fuel supply to engine

a) Flame arresters are to be provided at the inlet to the gas supply manifold for the engine.

b) Arrangements are to be made so that the gas supply to the engine can be shut-off manually from manoeuvring platform or any other control position.

c) The arrangement and installation of the gas piping are to provide the necessary flexibility for the gas supply piping to accommodate the oscillating movements of DFD engine, without risk of fatigue failure.

d) The connections of gas line and protection pipes or ducts required in 4.13.1.9(a) to the gas fuel injection valves are to provide complete coverage by the protection pipe or ducts.

4.13.1.9 Gas fuel supply piping systems

a) Gas fuel piping may pass through or extend into machinery spaces or gas-safe spaces other than accommodation spaces, service spaces and control locations provided that they fulfill one of the following:

i) The system when complying with 16.3.1.1 of Pt.5, Ch.4, Sec.16 of the 'Rules and Regulations for the Construction and Classification of Steel Ships' and in addition, with 1), 2) and 3) given below:

1) The pressure in the space between concentric pipes is monitored continuously. Alarm is to be issued and automatic valves specified in Cl. 16.3.6 of Pt.5, Ch.4, Sec.16 of the 'Rules and Regulations for the Construction and Classification of Steel Ships' and the master gas fuel valves specified in Cl.16.3.7 of Pt.5, Ch.4, Sec.16 of the 'Rules and Regulations for the construction and Classification of Steel Ships' are to be closed before the pressure drops to below the inner pipe pressure (however, an interlocked gas valve connected to vent outlet is to be opened).

2) Construction and strength of the outer pipes are to comply with the requirements of Pt.5, Ch.4, Sec.5, Cl.5.2 of the 'Rules and Regulations for the Construction and Classification of Steel Ships'.

3) It is to be so arranged that the inside of the gas fuel supply piping system between the master gas valve and the DFD engine is to be automatically purged with inert gas, when the master gas valve is closed; or

ii) The system when complying with Cl. 16.3.1.2 of Pt.5, Ch.4, Sec.16 of the 'Rules and Regulations for the construction and Classification of Steel Ships' and in addition, with 1) through 4) given below:

1) Materials, construction and strength of protection pipes or ducts and mechanical ventilation systems are to be sufficiently durable against bursting and rapid expansion of high pressure gas in the event of gas pipe burst.

2) The capacity of mechanical ventilating system is to be determined considering the flow rate of gas fuel and construction and arrangement of protective pipes or ducts, as deemed appropriate by the Rules of IRS.

3) The air intakes of mechanical ventilating systems are to be provided with non-return devices effective for gas fuel leaks. However, if a gas detector is fitted at the air intakes, these requirements may be dispensed with.

4) The number of flange joints of protective pipes or ducts is to be minimised; or

iii) Alternative arrangements to those given in paragraph 4.13.1.9(i) and 4.13.1.9(ii) will be specially considered based upon an equivalent level of safety.

b) High pressure gas piping system are to be ensured to have sufficient constructive strength by carrying out stress analysis taking into account the stresses due to the weight of the piping system including acceleration load when significant, internal pressure and loads induced by hog and sag of the ships.

c) All valves and expansion joints used in high pressure gas fuel supply lines are to be of an approved type.

d) Joints on entire length of the gas fuel supply lines are to be butt-welded joints with full penetration and to be fully radiographed, except where specially approved by IRS.

e) Pipe joints other than welded joints at the locations specially approved by IRS are to comply with the appropriate National or International standards or those whose structural strength has been verified through tests and analysis as deemed appropriate by IRS.

f) For all butt-welded joints of high pressure gas fuel supply lines, post-weld heat treatment are to be performed depending on the kind of material.

4.13.1.10 Shut-off of gas fuel supply

a) In addition to the causes specified in Pt.5, Ch.4, Sec.16, Cl. 16.3.6 of the 'Rules and Regulations for the construction and Classification of Steel Ships' supply of gas fuel to DFD engines is to be shut off by the interlocked gas valves in case following abnormality occurs:

i) Abnormality specified in 4.13.1.7

ii) DFD engine stops from any cause

iii) Abnormally specified in 4.13.1.9(a)(i).

b) In addition to the causes specified in Pt.5, Ch.4, Sec.16, Cl.16.3.7 of the 'Rules and Regulations for the construction and Classification of Steel Ships', the master gas valve is to be closed in case of any of the following:

i) Oil mist detector or bearing temperature detector specified in 4.13.1.3(b)(iii) and (c) detects abnormality.

ii) Any kind of gas fuel leakage is detected

iii) Abnormality specified in 4.13.1.9

iv) Abnormality specified in 4.13.1.11(a).

c) The master gas valve is to close automatically upon activation of the interlocked gas valves.

4.13.1.11 Emergency stop of the DFD engines

a) DFD engine is to stopped before the gas concentration detected by the gas detectors specified in Pt.5, Ch.4, Sec.16, Cl.16.2.2 of the 'Rules and Regulations for the Construction and Classification of Steel Ships', reaches 60% of lower flammable limit.

4.13.1.12 Gas fuel make-up plant and related storage tanks

a) Construction, control and safety system of high pressure gas compressors, pressure vessels and heat exchangers constituting a gas fuel make-up plant are to be arranged to the satisfaction of IRS.

b) The possibility for fatigue failure of the high pressure gas piping due to vibration is to be considered.

c) The possibility for pulsation of gas fuel supply pressure caused by the high pressure gas compressor is to be considered.

Section 5

Gearing

5.1 Scope

5.1.1 The requirements of this Section cover the construction, material and inspection of reduction gears for main propelling purposes and for driving electric generators.

5.1.2 Design of bevel gears will be specially considered.

5.1.3 For torsional vibration requirements, See Sec.8.

5.1.4 Rated power of gear is the maximum transmitted power at which the gear is designed to operate continuously at its rated speed.

5.1.5 The rated torque is defined by the rated power and speed and is the torque used in the gear rating calculations.

5.1.6 The gear rating is the rating for which the gear is designed to transmit it’s rated torque.

5.2 Plans and particulars

5.2.1 The following plans, in triplicate, of the reduction gearing are to be submitted:

For Approval

a) Pinion(s) and wheel(s);

b) Shafts;

c) Hub(s);

d) Other power transmitting parts;

For information only

e) Longitudinal and transverse sections of the gear box;

f) Clutch(es) and/or coupling(s);

g) Gear casing including propeller thrust bearing housing, if applicable.

5.2.2 The plans are to show clearly all dimensions, details of all fillets and stress raisers, and material of all the parts.

5.2.3 At least the following particulars of the gearing are to be submitted along with the plans:

a) Shaft power and revolutions for each pinion;

b) Number of teeth in each gear;

c) Generating pitch diameters;

d) Helix angles at generating pitch diameters;

e) Normal pitches of teeth at generating pitch diameters;

f) Tip diameters;

g) Root diameters;

h) Face widths and gaps, where applicable;

i) Pressure angles of teeth (normal or transverse) at generating pitch diameters;

j) Minimum backlash;

k) Centre distance;

l) Basic rack tooth form;

m) Details of tooth flank corrections, if adopted;

n) Details of post hobbing process, if any;

o) Case depth for surface-hardened teeth;

p) Shrinkage allowance for shrunk-on rims and hubs;

q) Type of coupling proposed for oil engine applications.

5.2.4 Gears with Multiple Prime Mover Inputs

5.2.4.1 For single helical gears with arrangements utilizing multiple prime mover inputs, and single or multiple outputs, the following analyses for all operating modes are to be conducted:

- All bearing reactions
- Tooth modifications
- Load distributions on the gear teeth
- Contact and tooth root bending stresses

A summary of the results of these analyses for each operating mode is to be submitted for review.

5.3 Materials

5.3.1 Specifications for materials of pinions, pinion sleeves, wheel rims, gear wheels and shafting giving chemical composition, heat treatment and mechanical properties are to be submitted for approval with the plans of gearing and are to be in accordance with Pt.2.

5.3.2 Where the teeth of a pinion or gear wheel are to be surface hardened, the proposed specification and details of the procedure are to be submitted for approval.

5.3.3 In the selection of materials for pinions and wheels consideration should be given to their compatibility in operation. In general, for gears of through hardened steels, except in the case of low reduction ratios, provision should also be made for a hardness differential between pinion teeth and wheel teeth. For this purpose the specified minimum tensile strength of the wheel materials should not be more than 85 per cent of that of the pinion.

5.3.4 Subject to 5.3.3, the specified minimum tensile strength of steel gear forgings is to be selected within the following limits:

- Pinions and pinion sleeves - 550-1050 [N/mm^2];

- Gear wheels and rims - 400-850 [N/mm^2].

A tensile strength range is also to be specified and is not to exceed 120 [N/mm^2] when the specified minimum tensile strength is 600 [N/mm^2] or less. For higher strength steels, the range is not to exceed 150 [N/mm^2].

5.3.5 Unless otherwise agreed, the specified minimum tensile strength of the core is to be 800 [N/mm^2] for induction-hardened or nitrided gearing and 750 [N/mm^2] for carburized gearing.

5.4 Design and construction

5.4.1 The design and construction is to be such as to enable the gearing to meet the general requirements with respect to functional capability and reliability.

5.4.2 Detailed analysis to prove the design of the gearing is to be submitted for consideration. In this regard, Classification Notes on the design of gearing may be followed.

5.4.3 Where castings are used for wheel centres, any radial slots in the periphery are to be fitted with permanent chocks before shrinking-on the rim.

5.4.4 Where bolts are used to secure side plates to rim and hub, the bolts should be tight fit with the holes and the nuts should be suitably locked by means other than welding.

5.4.5 When welding is employed in the construction of wheels, the welding procedure is to be approved by the Surveyors before work is commenced. For this purpose, welding procedure approval tests are to be carried out with satisfactory results. Such tests are to be representative of the joint configuration and materials. Wheels are to be stress relieved after welding. All welds are to have a satisfactory surface finish and contour. Magnetic particle or liquid penetrant examination of all important welding joints is to be carried out to the satisfaction of the Surveyors.

5.4.6 In general arrangements are to be made so that the interior structure of the wheel may be examined. Alternative proposals will be specially considered.

5.5 Accuracy of gear cutting and alignment

5.5.1 Gears are to be cut only on machines which are maintained at a high standard of accuracy. Hobbing machines used in the production of large gears are to be operated under conditions of temperature control with a total temperature variations not exceeding 2°C for the finishing cut. The blank should be allowed sufficient time to stabilize to the machine temperature before cutting commences.

5.5.2 The accuracy of gear-cutting of pinions and wheels is to be demonstrated to the satisfaction of the Surveyors. For this purpose, records of measurements of pitch error, undulations, axial pitch errors, tooth thickness and backlash should be available for review by Surveyors on request.

5.5.3 The alignment is to be demonstrated in the workshop by meshing in the gearbox without oil clearance in the bearings, or in the meshing frame without oil clearance in the bearings or on rollers. Meshing is to be carried out with the gears locating in their load positions, and a load sufficient to overcome pinion weight and axial movement is to be imposed.

5.5.4 A permanent record is to be made of the meshing contact for the purpose of re-checking the alignment when installed on board ship. The meshing contact on each helix is not to be less than following:

a) For through-hardened gears,

  - 40 per cent of the working depth for 35 per cent of the length; and

  - 20 per cent of the working depth for further 35 per cent of the length;

b) For through-hardened gears and for all surface hardened gears,

  - 40 per cent of the working depth for 50 per cent of length; and

  - 20 per cent of the working depth for a further 40 per cent of the length.

5.6 Balancing of gear pinions and wheels

5.6.1 All pinions, gear wheels and flexible couplings or sleeves whose maximum designed speed of rotation exceeds 1000 revolutions per minute are to be dynamically balanced, where the speed of rotation is 1000 revolutions per minute or less, these components are to be statically or, alternatively, dynamically balanced. Parts of couplings, etc., which are to be fixed to the gear in service are normally to be attached before balancing.

5.6.2 For static balancing the final out of balance of each assembly at the balancing planes is not to exceed 2200 [N mm/tonne] of gears whose maximum design speed is less than 300 revolutions per minute and 680 [N mm/tonnes] for gears whose maximum design speed is between 300 and 1000 revolutions per minute. For dynamic balancing the final out of balance is not to exceed 190,000/N_1 [N mm/tonne], where N_1 = revolutions per minute appropriate to the assembly.

5.6.3 Balancing may, however, be omitted for turbine secondary pinions and for oil engines gearing, provided that the rotating components are of solid forged construction or have a solid forged centre with shrunk-on rim and in both cases are machined to give a concentric and uniform cross-section.

5.7 Gearcases

5.7.1 Gearcases and their supports are to be designed sufficiently stiff such that misalignment at the mesh due to movements of the external foundations and the thermal effects under all conditions of service do not disturb the overall tooth contact. If welding is employed in their construction they are to be stress-relieved on completion.

5.7.2 Inspection openings should be provided at the peripherals of gearcases to enable the teeth of pinions and wheels to be readily examined. When the construction of gearcases is such that sections of the structure cannot readily be moved for inspection purposes, access openings of adequate size are to be also provided at the ends of the gearcases to permit examination of the structure of the wheels. Their attachment to the shafts should be capable of being examined by removal of bearing caps or by equivalent means.

5.8 Type tests and sea trials

5.8.1 Upon completion of fabrication and assembly, reduction gear unit is to be subjected to type testing in accordance with the agreed test programme which is to be submitted by the manufacturer for approval. Type tests are to be witnessed by the Surveyor.

5.8.2 Reduction gearing units, in general, are to be type tested at maker’s works and test load and duration of testing is to be agreed upon in each case.

5.8.3 Tests are to include demonstration of satisfactory operation of clutches and couplings, if fitted.

5.8.4 After completion of type tests, all gear elements are to be examined for tooth contact marking and alignment. All gear tooth contact is to conform to the requirements given in Cl. 5.5.5.

5.8.5 The gear lub.oil system is to be provided with means of indicating the lub.oil pressure supply to them. Alarms are to be provided to indicate low lub.oil pressure, low clutch oil/air pressure and high lub.oil temperature in accordance with Part 4, Chapter 7, Table 1.9.1.

5.9 Alignment and weardown gauges

5.9.1 Reduction gears with sleeve bearings for main and auxiliary turbines and oil engines, are to be provided with weardown gauges or micrometers for testing the internal alignment of the various elements in the gearcases. In certain gears, e.g. gears of the dual tandem type, the direction of loading on the bearings of a gear element may be such that an accurate indication of its alignment under operating conditions cannot be obtained using weardown gauges. In these instances, suitable alternatives such as crown thickness micrometer are to be provided.

5.9.2 Approved means are to be provided by the gear manufacturer to enable the Surveyors to verify that no distortion of the gearcase has taken place, when chocked and secured to its seating on board ship.

5.10 Trials

5.10.1 The sea trials should be of sufficient duration to prove the gears. After these trials, the marking revealed by inspection should indicate freedom from hard bearings, particularly towards both ends of each helix.

5.10.2 In the case of through-hardened gears, not less than 70 per cent contact across effective face width should be indicated. When the teeth of such gears are finished by an approved post hobbing process or profile ground, not less than 90 per cent contact across the effective face width is to be indicated.

5.10.3 For surface hardened gears, the contact across the effective face width is also to be not less than 90 per cent.

Section 6

Main Propulsion Shafting

6.1 Scope

6.1.1 The requirements of this Section apply to shafting for main propulsion of straight forged design and which are driven by rotating machines such as diesel engines, turbines or electric motors. The requirements for couplings, coupling bolts, keys, keyways, sternbushes and associated components are also included. The diameter of shafting as calculated may require to be modified as a result of alignment considerations and vibration characteristics (See Sec.8) or the inclusion of stress raisers, other than those contained in this section.

The requirements given in this section do not cover shafts intended for following application.

- gearing shafts
- electric motor shafts
- generator rotor shafts
- turbine rotor shafts.

6.1.2 The scantlings of shafts that are integral to equipment, such as for gear boxes, podded drives, electrical motors and/or generators, thrusters, turbines and which in general incorporate particular design features are to be determined taking into account appropriate additional criteria including that for stiffness, high temperature application etc. The requirements given in this section may be applied if such shafts are subjected mainly to torsion and are having traditional design features.

6.1.3 For additional strengthening for shafts in ships classed for navigation in waters with ice condition, refer Pt.5, Ch.21 and for diesel engine crankshaft refer IRS Classification Note “Crankshaft for Internal Combustion Engines”.

6.2 Alternative calculation methods

6.2.1 Alternative calculation methods will be considered provided these calculations take into account all relevant loads in the complete dynamic shafting system under all permissible operating conditions giving due consideration to the dimensions and arrangements of all shafting connections. The alternative calculation method is to also take into account design criteria for continuous and transient operating loads for dimensional adequacy for fatigue strength and peak operating loads for yield strength. Refer 6.2.2 to 6.2.5 as guidance for alternative calculations.

6.2.2 The two important considerations that are essential for the design of propulsion shafting are:

a) Fatigue
b) Stress concentration and notch sensitivity.

***Fatigue** : The deterioration of the properties of material which takes place under conditions involving fluctuating stresses. Fatigue failures generally occur at loads, which if applied statically would be below the elastic limit. The fatigue limit of a material is the stress which will not produce failure, even if many fluctuations of it are imposed.*

***Stress concentration in shafts** : Basic stress analysis calculations assume that the components are smooth, have a uniform section and have no irregularities. In practice virtually all engineering components have to have changes in section and/or shape. Common examples are shoulders on shafts, oil holes, key ways and screw threads. Any discontinuity changes the stress distribution in the vicinity of the discontinuity, so that the basic stress analysis equations no longer apply. Such ‘discontinuities’ or ‘stress raisers’ cause local increase of stress referred to as ‘stress concentration’.*

For static loading the theoretical or geometric stress concentration factors K_t or K_{ts} relate to actual maximum stress at the discontinuity to the nominal stress as follows:

K_t = maximum direct stress/nominal direct stress
K_{ts} = maximum shear stress/nominal shear stress.

The subscript ‘t’ denotes that the stress concentration value is a theoretical calculation based only on the geometry of the component and discontinuity.

Some materials are not as sensitive to notches as implied by the theoretical stress concentration factor. For these materials a reduced value of stress concentration factor K_f may be used where the maximum stress = K_f x nominal stress. The value of K_f which depends on notch sensitivity ‘q’ is to be determined using the following equation:

$q = (K_f - 1) / (K_t - 1)$ where q is between 0 and 1.

If q = 0, then $K_f = 1$ as the material has no sensitivity to notches. If q = 1, then $K_f = K_t$ and the material is fully notch sensitive.

When designing, usual practice is to first find K_t from the geometry of the component, then specify the material and determine the notch sensitivity, q from the chart for the notch radius.

For cyclic loading, the theoretical stress concentration factor is to be defined as

$$K_{t1} = \frac{\text{endurance limit without stress concentration}}{\text{endurance limit with stress concentration}}$$

Using the notch sensitivity factor ‘q’ in cyclic loading of shaft, fatigue stress concentration factor K_f is calculated as :

$$K_f = 1 + q\,(K_{t1} - 1)$$

6.2.3 The alternative calculation methods are to take into account following fatigue related issues as have been considered in rule formulations:

a) Low cycle fatigue criterion (typically < 10^4), i.e. the primary cycles represented by zero to full load and back to zero, including reversing torque if applicable.

b) High cycle fatigue criterion (typically > 10^7), i.e. torsional vibration stresses permitted for continuous operation as well as reverse bending stresses.
The limits for torsional vibration stresses are given in 8.4.2.

c) The accumulated fatigue due to torsional vibration when passing through a barred speed range or any other transient condition with associated stresses beyond those permitted for continuous operation is addressed by the criterion for transient stresses in 8.4.2.

6.2.4 The factors k (for low cycle fatigue) and c_k (for high cycle fatigue) as given in Table 6.5.1 and Table 8.4.2 respectively take into account the influence of:

- The stress concentration factors (scf) relative to the stress concentration for a flange with fillet radius of $0.08d_o$ (geometric stress concentration of approximately 1.45).

$$c_k \approx \frac{1.45}{scf} \quad \text{and} \quad k \approx \left[\frac{scf}{1.45}\right]^x$$

where the exponent x considers low cycle notch sensitivity.

- The chosen values of the notch sensitivity are mainly representative for soft steels (σ_B < 600), while the influence of steep stress gradient s in combination with high strength steels may be underestimated.

- The size factor C_D being a function of diameter only does not purely represent a statistical size influence, but rather a combination of this statistical influence and the notch sensitivity.

6.2.5 The stress concentration factor (scf) at the end of slots can be determined by means of the following empirical formulae:

$$scf = \alpha_{t(hole)} + 0.8\,.\frac{(l - e)/d}{\sqrt{\left(1 - \frac{d_i}{d}\right).\frac{e}{d}}}$$

where,

e = slot width
l = length of the slot
d_o = outer diameter
d_i = inner diameter (Refer figure given under Table 6.5.1).

This formula applies to:

- slots at 120 or 180 or 360 degrees apart.

- slots with semicircular ends. (Though multi-radii slot end can reduce the local stresses, this is not included in this empirical formula).

- slots with no edge rounding (except chamfering), as any edge rounding increases the scf slightly.

$\alpha_{t(hole)}$ = factor representing the stress concentration of radial hole of diameter e:

$$= 2.3 - 3.\frac{e}{d} + 15.\left(\frac{e}{d}\right)^2 + 10.\left(\frac{e}{d}\right)^2.\left(\frac{d_i}{d}\right)^2$$

6.3 Plans and particulars

6.3.1 The following plans, in triplicate, together with the necessary particulars of the machinery, including the maximum power and revolutions per minute, are to be submitted for approval before the work is commenced.

- Power take-off arrangement if any (e.g. shaft generator), propulsion boosters or similar equipment rated for 100 [kW] and above;
- Final gear shaft;
- Thrust shaft;
- Intermediate shafting, shaft bearings;
- Tube shaft, where applicable;
- Tail shaft;
- Stern tube, shaft seals and Stern bush;
- Stern tube lubrication system;
- Couplings (integral, demountable, keyed or shrink-fit), coupling bolts and keys;
- Flexible coupling including constructional details, static and dynamic torsional stiffness, damping characteristic, rated power, torque and RPM, allowable vibratory torque for continuous and transient operation and allowable misalignment for continuous operations;
- Cardan shafts, if fitted.

6.3.2 The specified minimum tensile strength of each shaft is to be stated.

6.3.3 A shafting arrangement plan indicating the relative position of the main engines, flywheel, flexible coupling, gearing, thrust block, line shafting and bearings, stern tube, 'A' brackets and propeller, as applicable, is to be submitted for information.

6.4 Materials for shafting

6.4.1 The materials are to comply with the relevant requirements of Pt.2, Ch.5. The specified minimum tensile strength of forgings is to be selected within the following general limits:

a) Carbon and carbon-manganese steel 400-760 [N/mm^2];

b) Alloy steels - 400-800 [N/mm^2];

Where shafts may experience vibratory stresses close to the permissible stresses for transient operation, the materials are to have a specified minimum tensile strength of 500 [N/mm^2].

6.4.2 If materials with greater specified or actual tensile strength than the limitations given in 6.4.1 are used, no consideration will be given for reduction of shaft diameter or acceptance of higher permissible vibratory stresses, than those stated in 6.4 to 6.6.

6.4.3 Ultrasonic tests are required on shaft forgings where the diameter is 250 [mm] or greater.

6.5 Intermediate and thrust shafts

6.5.1 The diameter, d, of the shaft is to be not less than determined by the following formula:

$$d = Fk\sqrt[3]{\frac{P}{n}\left(\frac{560}{\sigma B + 160}\right)}\ [\mathrm{mm}]$$

where,

F = 95 for turbine installations, electric propulsion installations and oil engine installations with slip type couplings;

= 100 for other oil engine installations;

k = shaft design factors as given in Table 6.5.1;

σB = specified minimum tensile strength of the material [N/mm^2] as per 6.4.1.

P = maximum shaft power, in [kW];

n = Revolutions per minutes corresponding to maximum shaft power giving maximum torque.

6.5.2 For shafts with design features other than stated in Table 6.5.1, the value of k will be specially considered.

Table 6.5.1 : Shaft design factors k for line shafts and thrust shafts

Factor	Intermediate shaft with					Thrust shafts external to engine		
	Integral coupling flange 1)	Shrink fit coupling 2)	Key-ways cylindrical and tapered 3), 4)	Radial holes, transverse holes 5)	Longitudinal slots 6)	On both sides of thrust collars 1)	In way of axial bearings where a roller bearing is used for taking up thrust	Straight sections
k	1.0	1.0	1.1	1.1	1.2	1.1	1.1	1.0

Notes:

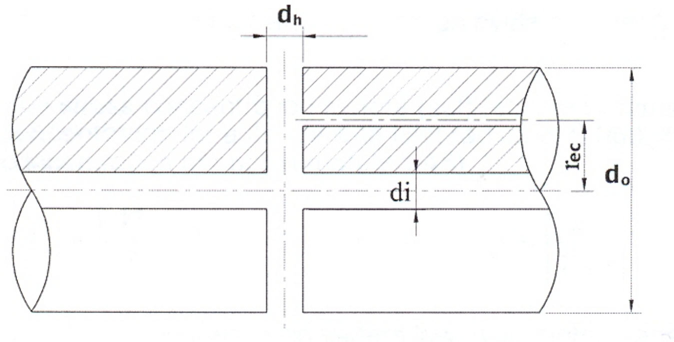
1) Fillet radius is not to be less than 0.08d.

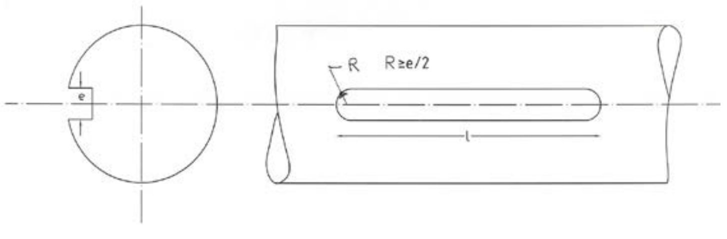
2) k refers to the plain shaft section only. Where shafts may experience vibratory stresses close to the permissible stresses for continuous operation, an increase in diameter to the shrink fit diameter is to be provided, e.g. a diameter increase of 1 to 2% and a blending radius nearly equal to the change in diameter are to be provided.

3) At a distance of not less than 0.2d from the end of the keyway the shaft diameter may be reduced to the diameter calculated with k = 1.0. Fillet radii in the transverse section of the bottom of the key way are not to be less than 0.0125d.

4) It is recommended that keyways are in general not to be used in installations with a slow speed crosshead or 2-stroke engines with a barred speed range.

5) Diameter of radial bore (d_h) not to exceed $0.3d_o$.
The intersection between a radial and an eccentric (r_{ec}) axial bore (see below) the value will be determined on the basis of data submitted in each case.





6) Subject to following limitations being complied with -

i) slot length (l)/outside diameter < 0.8 and
ii) inner diameter (d_i)/outside diameter d_o < 0.7 and
iii) slot width (e)/outside diameter d_o > 0.15.
The end rounding of the slot is not to be less than e/2. An edge rounding should preferably be avoided as this increases the stress concentration slightly. The k value is valid for 1, 2 and 3 slots and they are to be arranged 360, 180 or 120 degrees apart from each other respectively.

6.6 Tailshafts and stern tube shafts

6.6.1 The diameter, d_p, of the tailshaft immediately forward of the forward face of the propeller boss or, if applicable, the forward face of the tailshaft flange, is to be not less than determined by the following formula:

$$d_p = 100\,k\,\sqrt[3]{\frac{P}{n}\left(\frac{560}{\sigma B + 160}\right)}\ \text{[mm]}$$

where,

k = shaft design factors as given in Table 6.6.1;

σB = specified minimum tensile strength of the material [N/mm^2]. For calculation purposes, this value is not to be taken greater than 600 [N/mm^2] (for carbon, carbon manganese and alloy steels);

P and n are defined in 6.5.

6.6.2 The diameter, d_p of the tailshaft determined in accordance with the formula in 6.6.1 is to extend over a length not less than that to the forward edge of the bearing immediately forward of the propeller or 2.5 d_p whichever is the greater.

6.6.3 The diameter of the portion of the tailshaft and tubeshaft forward of the length required by 6.6.2 to the forward end of the forward sterntube seal is to be determined in accordance with the formula in 6.6.1 except that:

Table 6.6.1 : Shaft design factors k for tailshafts 1) and stern tube shafts

Factor	Propulsion drive	Stern tube configuration	Tailshafts : propeller attachment method			Stern tube shafts
			Keyed	Key less attachment by shrink fit	Flanged	
k	All	Oil lubricating bearings and provided with an approved type of oil seating gland	1.26	1.22	1.22	1.15
	All	Water lubricated bearings : continuous shaft liners / shafts of corrosion resistant material or equivalent	1.26	1.22	1.22	1.15
	All	Water lubricated bearings : non-continuous shaft liners	1.29	1.25	1.25	1.18

Note : 1) Fillet radii in the transverse section at the bottom of the keyway are not to be less than 0.0125d_p

k = 1.15, where k = 1.22 or 1.26 as required by 6.6.1 (shafts fitted with continuous liner or oil lubricated);

k = 1.18, where k = 1.25 or 1.29 as required by 6.5.1 (shafts with water lubricated bearings).

The change of diameter from that required by 6.6.1 to that required by this clause should be gradual.

6.6.4 Tailshafts which run in sterntubes and tube shafts may have the diameter forward of the forward stern tube seal gradually reduced to the diameter of the intermediate shaft. Abrupt changes in shaft section at the tailshaft/tubeshaft to intermediate shaft couplings are to be avoided.

6.7 Hollow shafts

6.7.1 For hollow shafts where the bore exceeds 40 per cent of the outside diameter the minimum shaft diameter is not to be less than that given by the following equation:

$$d_o = d\,\sqrt[3]{\frac{1}{1-\left(\frac{d_i}{d_o}\right)^4}}\ \ \text{[mm]}$$

where,

d_o = outside diameter [mm];

d = Rule size diameter of shaft [mm], calculated in accordance with 6.5 or 6.6;

d_i = diameter of central hole [mm].

6.7.2 Where the diameter of central hole does not exceed 0.4 times the outside diameter, no increase over Rule size need be provided.

6.8 Integral couplings

6.8.1 The thickness of coupling flanges is not to be less than the minimum required diameter of the coupling bolts calculated as in para 6.9, with tensile strength of the bolt material being taken as the tensile strength of the corresponding shaft material or 0.2 times the rule diameter of the shaft under consideration, whichever is greater. Special consideration will be given by IRS for flanges having non-parallel faces; however, in such cases the thickness of the flanges is not be less than the coupling bolt diameter.

6.8.2 The fillet radius at the base of the coupling flange is to be not less than 0.08 of the diameter of the shaft at the coupling. The fillets are to have a smooth finish and are not to be recessed in way of nuts and bolt heads. The fillet may be formed of multiradii in such a way that the stress concentration factor will not be greater than for a circular fillet with radius 0.08 times the actual shaft diameter.

6.8.3 Where the propeller is attached by means of a flange, the thickness of the flange is to be not less than 0.25 times the actual diameter of the adjacent part of the tailshaft. The fillet radius at the base of the coupling flange is to be not less than 0.125 times the diameter of the shaft at the coupling.

6.9 Demountable couplings

6.9.1 Couplings are to be made of steel or other approved ductile material. The strength of demountable couplings and keys is to be equivalent to that of the shaft. Couplings are to be accurately fitted to the shaft.

6.9.2 Hydraulic and other shrink fit couplings will be specially considered upon submittal of detailed preloading and stress calculations and fitting instructions. In general, the torsional holding capacity is to be at least 2.8 times the transmitted torque and preload stress is not to exceed 70 per cent of the yield strength.

6.9.3 Provision is to be made to resist astern pull.

6.10 Tooth couplings

6.10.1 The contact stress, σ_c, at the flanks of mating teeth of a gear coupling is not to exceed that given in Table below, where:

$$\sigma_c = \frac{24 \mathrm{x} 10^6 \mathrm{P}}{\mathrm{n d_p \, bhz}} \; [\mathrm{N/mm^2}]$$

P and n are defined in 6.4.1.

d_p = pitch circle diameter of coupling teeth [mm]

b = tooth facewidth [mm]

h = tooth height [mm]

z = number of teeth (per coupling half).

Allowable σ_c values	
Tooth material surface treatment	**Allowable σ_c value [N/mm^2]**
Surface hardened teeth	19
Through hardened teeth	11

6.10.2 Where experience has shown that under similar operating and alignment conditions, a higher tooth loading can be accommodated full details are to be submitted for consideration.

6.11 Flexible couplings

6.11.1 Details of flexible couplings are to be submitted together with the manufacturers' rating capacity, for the designed operating conditions including short term high power operation. Verification of coupling characteristics will be required.

6.11.2 In determining the allowable mean, maximum and vibratory torque ratings, consideration of the mechanical properties of the selected elastic element type in compression, shear and fatigue loading together with heat absorption/generation is to be given.

6.11.3 In determining the allowable torque ratings of the steel spring couplings, consideration of the material mechanical properties to withstand fatigue loading and overheating is to be given.

6.12 Interference fit assemblies

6.12.1 The interference fit assembly is to have a capacity to transmit a torque Q without slippage.

$Q = 9550 \frac{P}{n} (1+C) . S$ [N-m]

Where,

P = power transmitted, kW

n = RPM of the shaft

C = coefficient as per Table 6.12.1

S = 2.0 for assemblies accessible from within the vessel

= 2.5 for assemblies not accessible from within the vessel.

Table 6.12.1 : 'C' values for guidance purposes

Coupling Location	C
High Speed Shafting - IC engine driven	0.3
High Speed Shafting - Electric Motor or Turbine driven	0.1
Low Speed Shafting - Main or PTO stage gearing	0.1

6.12.2 The effect of any axial load acting on the assembly is to be considered.

6.12.3 The resulting equivalent von Mises stress in the assembly is not to be greater than the yield strength of the component material.

6.12.4 Reference marks are to be provided on the adjacent surfaces of parts secured by shrinkage alone.

6.13 Coupling bolts

6.13.1 The diameter of the fitted bolts at the joining faces of the coupling is to be not less than that given by the following formula:

$$d_b = 0.65 \sqrt{\frac{d^3 (T + 160)}{i D T_b}}$$

where,

d_b = diameter of the fitted coupling bolts [mm];

d = required diameter [mm], of the intermediate shaft taking into account ice strengthening requirements, if applicable;

T = specified minimum tensile strength of the shaft material [N/mm^2];

T_b = specified minimum tensile strength of the bolt material [N/mm^2];

= and also $T \le T_b \le 1.7$ T, but not higher than 1000 [N/mm^2]

i = number of bolts in the coupling;

D = pitch circle diameter of bolt holes [mm].

6.13.2 The diameter of the non-fitted bolts will be specially considered upon the submittal of detailed preloading and stress calculations and fitting instructions.

6.14 Tailshaft liners

6.14.1 The thickness, t, of bronze or gunmetal liners fitted on tailshafts, in way of bearings, is not to be less than given by following formula:

$$t = \frac{168 + d_p}{28} \text{ [mm]}$$

where,

t = thickness of liner [mm];

d_p = diameter of tailshaft under the liner [mm].

6.14.2 The thickness of the continuous liner between the bearings is not be less than 0.75t.

6.14.3 Continuous liners are preferably to be cast in one length. If made of several lengths, the joining of the separate pieces is to be made by welding through the whole thickness of liner before shrinking. In general, the lead content of the gunmetal of each length forming a butt welded liner is not to exceed 0.5 per cent. The composition of the electrode or filler rods is to be substantially lead free.

6.14.4 The liners are to withstand a hydraulic pressure of 2.0 bar after rough machining.

6.14.5 The liners are to be carefully shrunk or forced upon the shaft by hydraulic pressure, and they are not to be secured by pins.

6.14.6 Effective means are to be provided for preventing water from reaching the shaft at the part between the after end of the liner and the propeller boss.

6.14.7 If the liner does not fit the shaft tightly between the bearing portions in the stern tube, the space between the shaft and the liner is to be filled with a plastic insoluble non-corrosive compound.

6.15 Keys and keyways for propeller connections

6.15.1 Round ended or sled-runner ended keys are to be used, and the key ways in the propeller boss and cone of the tailshaft are to be provided with a smooth fillet at the bottom of the keyways. The radius of the fillet is to be at least 0.0125 of the diameter of the tailshaft at the top of the cone. The sharp edges at the top of the keyways are to be removed.

6.15.2 Two screwed pins are to be provided for securing the key in the keyway, and the forward pin is to be placed at least one-third of the length of the key from the end. The depth of the tapped holes for the screwed pins is not to exceed the pin diameter and the edges of the holes are to be slightly beveled.

6.15.3 The distance between the top of the cone and the forward end of the keyway is to be not less than 0.2 of the diameter of the tailshaft at the top of the cone.

6.15.4 The effective sectional area of the key in shear, is to be not less than $\dfrac{d^3}{2.6\,d_1}$ [mm^2]

where,

d = diameter [mm], required for the intermediate shaft determined in accordance with 6.4, based on material having a specified minimum tensile strength of 400 [N/mm^2] and k = 1;

d_1 = diameter of shaft at mid-length of the key [mm].

6.16 Stern tube and bearings

6.16.1 The length of the bearing in the sternbush next to and supporting the propeller is to be as follows:

a) For water lubricated bearings which are lined with lignum vitae, rubber composition or staves of approved plastic material; the length is to be not less than 4 times the diameter required for the tailshaft under the liner;

b) For bearings which are white-metal lined, oil lubricated and provided with an approved type of oil sealing gland;

   i. the length of the bearing is to be not less than twice the diameter required for the tailshaft.

   ii. the length of the bearing may be less provided the nominal bearing pressure will not exceed 0.8 [N/mm^2] as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing divided by the projected area of the shaft. However, the length of the bearing is to be not less than 1.5 times its actual diameter;

b) For bearings of cast iron, bronze which are oil lubricated and fitted with an approved oil sealing gland; the length of the bearing is, in general, to be not less than 4 times the diameter required for tailshaft;

c) For bearings which are grease lubricated, the length of bearing is to be not less than 4 times the diameter required for the tailshaft;

d) For water lubricated bearings lined with two or more circumferentially spaced sectors of an approved plastics material, in which it can be shown that the sectors operate on hydrodynamic principles, the length of the bearing is to be such that the nominal bearing pressure will not exceed 0.55 [N/mm^2]. The length of the bearing is not to be less than twice its diameter;

e) For approved oil lubricated bearings of synthetic rubber, reinforced resin or plastic materials, the length of the bearing is to be not less than 2.0 times the rule diameter of the shaft in way of the bearing. The length of the bearing may be reduced provided the nominal pressure is not more than 6 bar as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing divided by the projected area of the shaft. In any case the length is not to be less than 1.5 times the actual diameter. Where the material has proven satisfactory testing and operating experience, consideration may be given to an increased bearing pressure.

6.16.2 Forced water lubrication is to be provided for all bearings lined with rubber or plastics and for those bearings lined with lignum vitae where the shaft diameter is 380 [mm] or over. The supply water may come from a circulating pump or other pressure source. The water grooves in the bearings are to be of ample section and of a shape which will be little affected by weardown, particularly for bearings of the plastic type.

6.16.3 The shut off valve or cock controlling the supply of water is to be fitted direct to the after peak bulkhead, or to the sterntube where the water supply enters the sterntube forward of the bulkhead.

6.16.4 Where a tank supplying lubricating oil to the sterntube is fitted, it is to be located above the load water line and is to be provided with a low level alarm device in the engine room.

6.16.5 Where sternbush bearings are oil lubricated, provision is to be made for cooling the oil by maintaining water in the after peak tank above the level of the sterntube or by other approved means. Means of ascertaining the temperature of the oil in the sternbush are also to be provided.
For vessels with TAILSHAFT CONDITION MONITORING (TCM) notation, at least two independent temperature sensors or other approved arrangements are to be provided for measuring the aft bearing temperature.

6.16.6 The oil sealing glands used for sterntube bearings, which are oil lubricated, are to be of approved type.

6.16.7 An arrangement for readily obtaining accurate oil samples is to be provided. The sampling point is to be taken from the lowest point in the lub.oil system as far as practicable. Also the arrangements are to be such as to permit the effective removal of the contaminants from the oil lubricating system.

6.16.8 Stern seals are to be of the axially direct face type. Soft packing glands are to be used only if specified by Owners.

6.16.9 Where bulkhead glands are fitted, a watertight sealing arrangement is to be provided. Bulkhead seals is not to be formed by a bulkhead mounted plummer bearing.

6.16.10 Plummer bearings are to be either bulkhead mounted or of pedestal type.

6.17 Roller element bearings

6.17.1 Roller element bearings are to have design life, L_{10h} not less than:

- 40,000 hours for propeller thrust bearing;

- 30,000 hours for other bearings.

Where L_{10h} is the basic rating life in hours which 90% of a sufficiently large group of apparently identical bearings is expected to attain.

6.18 Shaft bearing materials

6.18.1 Shaft bearing fitted in stern bushes and shaft bossings in "A" and "P" brackets are to be constructed from an approved material and effectively secured to prevent rotational and axial movement in the stern tube(s) and stern bush(es)

6.19 Glass Reinforced Plastic coating

6.19.1 The tail shaft may be protected by a fiberglass reinforced plastic coating between liners in accordance with the following procedure, which effectively prevents sea water from contacting the steel shaft. In such cases, the tailshaft survey interval would be 5 years as applicable for the tailshaft survey notation TS(CL). The procedure is to be approved in each case:

a) Coatings are to consist of at least 4 plies of cross-woven glass tape impregnated with resin or equivalent process.

b) The shaft is to be cleaned with solvent or grit blasted.

c) Shaft is to be examined and 1st coat is to be given in presence of Surveyors.

d) Shaft is to be subjected to spark test after coating. There should be freedom from porosity.

e) Effective means are to be provided to prevent water gaining access to the metallic region of the shaft.

f) It is to be ensured that provision is made for overlapping and adequate bonding of the coating.

g) The end of the liner is to stepped and tapered as required to protect the end of the wrapping.

Section 7

Propellers

7.1 Scope

7.1.1 The requirements of this Section cover the construction, materials and inspection of propellers.

7.2 Plans and particulars

7.2.1 A plan, in triplicate, of the propeller is to be submitted for approval, together with the following particulars:

a) Maximum shaft power, P, in [kW];

b) Revolutions per minute of the propeller at maximum power, R;

c) Propeller diameter, D [m];

d) Pitch at 25 per cent radius (for solid propellers only), $P_{0.25}$ [m];

e) Pitch at 35 per cent radius (for controllable pitch propellers only), $P_{0.35}$ [m];

f) Pitch at 70 per cent radius, $P_{0.7}$ [m];

g) Length of blade section of the expanded cylindrical section at 25 per cent radius (for solid propeller only), $L_{0.25}$ [mm];

h) Length of blade section of expanded cylindrical section at 35 per cent radius (for controllable pitch propellers only) $L_{0.35}$ [mm];

i) Rake at blade tip measured at shaft axis (backward rake positive, forward rake negative), K [mm];

j) Number of blades, N;

k) Developed area ratio, a.

7.2.2 In case of controllable pitch propeller following additional plans / data is to be submitted:

- Hub and it's attachments to tailshaft flange with connecting bolts
- Propeller blade flange and it's attachment bolts
- Internal control mechanisms
- Hydraulic piping control systems
- Instrumentation and alarm systems
- Strength calculations for internal components

In case of highly skewed propellers with skew angle greater than 50 degree and controllable pitch propeller skew angle greater than 25 degrees, propeller load and stress analysis proving adequacy of blade strength are to be submitted.

7.3 Materials

7.3.1 Castings for propellers and propeller blades are to comply with the requirement of Pt.2, Ch.8. The specified minimum tensile strength is to be not less than stated in Table 7.4.1.

7.3.2 When it is proposed to use materials which are not included in Table 7.4.1, details of the chemical composition, mechanical properties and density are to be submitted for approval.

7.4 Design

7.4.1 Minimum blade thickness

7.4.1.1 Where the propeller blades are of conventional design, the thickness, t, of the propeller blades at 25 per cent radius for solid propellers, at 35 per cent for controllable pitch propellers, neglecting any increase due to fillets, is to be not less than:

Table 7.4.1 : Material constants

Materials	Specified min. UTS [N/mm^2]	f	w
Manganese bronze Grade Cu 1	440	20.6	8.3
Ni-Manganese bronze Grade Cu 2	440	20.9	8.0
Ni-Aluminium bronze Grade Cu 3	590	25.7	7.5
Mn-Aluminium bronze Grade Cu 4	630	23.25	7.5
Cast iron	250	11.77	7.2
Carbon and low alloy steels	400	14.0	7.9
Note : The value of f may be increased by 10 percent for twin screw and outboard propellers of triple screw ships.			

a) For fixed propellers

$$t_{0.25} = 1055\sqrt{\frac{AP}{C_n CRN} + \frac{2.5BKC_s}{C\,C_n}}$$

b) For controllable pitch propellers

$$t_{0.35} = 847\sqrt{\frac{AP}{C_n CRN} + \frac{1.6\,BKC_s}{C\,C_n}}$$

where,

$t_{0.25}$ = minimum blade thickness required at 25 per cent radius;

$t_{0.35}$ = minimum blade thickness required at 35 per radius;

C_n = section modulus coefficient at 25 per cent radius or 35 per cent radius as applicable;

$= \dfrac{I_o}{U_f L T^2}$ and is not to be taken greater than 0.10;

I_o = moment of inertia of the expanded cylindrical section at 25 per cent radius or 35 per cent radius, as applicable, about a straight line passing through the center of gravity parallel to the pitch line or to the nose-tail line [mm^4];

U_f = maximum normal distance from the moment of inertia axis to points on the face boundary (tension side) of the section at 25 per cent radius or 35 per cent radius, as applicable [mm];

L = length of the blade section of the expanded cylindrical section at 25 per cent radius or 35 per cent radius, as applicable [mm];

T = maximum thickness of the expanded cylindrical section as approved at 25 per cent or 35 per cent radius, as applicable [mm];

C_s = section area coefficient at 25 per cent radius or 35 per cent radius as applicable;

$$= \frac{a_s}{L\,T}$$

a_s = area of the expanded cylindrical section at 25 per cent radius or 35 per cent radius, as applicable [mm^2];

f = material constant as per Table 7.4.1;

w = material constant as per Table 7.4.1;

a) For fixed-pitch propellers

$$A = 1.0 + \frac{6.0\,D}{P_{0.7}} + \frac{4.3\,P_{0.25}}{D}$$

$$B = \left(\frac{4300\,w\,a}{N}\right)\left(\frac{R}{100}\right)^2\left(\frac{D}{20}\right)^3$$

$$C = \left(1 + \frac{1.5P_{0.25}}{D}\right)\left(L_{0.25}\,f - B\right)$$

b) For controllable pitch propellers

$$A = 1.0 + \frac{6.0\,D}{P_{0.7}} + \frac{3.0\,P_{0.35}}{D}$$

$$B = \left(\frac{4900\,w\,a}{N}\right)\left(\frac{R}{100}\right)^2\left(\frac{D}{20}\right)^3$$

$$C = \left(1 + \frac{0.6P_{0.25}}{D}\right)\left(L_{0.35}\, f - B\right)$$

7.4.1.2 Propellers of unusual design or application will be subject to special consideration upon submittal of detailed stress calculations.

7.4.1.3 Fillets at the root of the blades are not to be considered in the determination of blade thickness.

7.4.2 Keyless propellers

7.4.2.1 Where propellers are fitted without keys, detailed stress calculations and fitting instructions are to be submitted for approval.

7.4.3 Controllable pitch propellers

7.4.3.1 In the case of controllable - pitch propellers, means are to be provided to lock the blades in ahead position in case of the failure of the pitch operating mechanism.

7.4.3.2 A propeller pitch indicator is to be fitted at each location from which it is possible to control the pitch of the propeller.

7.5 Fitting of propellers

7.5.1 The propeller boss is to be a good fit on the tailshaft cone. The forward edge of the bore of the propeller boss is to be rounded to about 6 [mm] radius. In general the contact area between propeller hub and tailshaft taper is to be not less than 70 per cent of the theoretical contact area. On completion of final pull-up propeller is to be secured.

7.5.2 The exposed part of the tailshaft is to be protected from the action of water by filling all spaces between propeller hub, cap and shaft with a suitable filling material. The propeller assembly is to be sealed at the forward end with a well-fitted soft rubber packing ring. When the rubber ring is fitted in an external gland, the hub counterbore is to be filled with suitable material, and clearances between shaft liner and hub counterbore are to be kept to a minimum. When the rubber ring is fitted internally, ample clearance is to be provided between liner and hub and the ring is to be sufficiently sized to squeeze in to the clearance space when the propeller is driven up on the shaft, and, where necessary, a filler piece is to be fitted in the propeller - hub keyway to provide a flat unbroken seating for the ring. The recess formed at the small end of the taper by the over hanging propeller hub is to be packed with red lead putty or rust-preventing compound before the propeller nut is put on.

7.5.3 Effective means are to be provided to prevent the slackening of the propeller nut.

Section 8

Vibrations and Alignment

8.1 Scope

8.1.1 The requirements of this Section are applicable to the following systems:

a) Main oil engine propulsion systems, except in the case of ships classed for smooth water service, when fitted with engines having powers less than 200 [kW].

b) Auxiliary oil engine machinery systems used for essential services, where the power developed by auxiliary engines is 200 [kW] and over.

c) Main propulsion systems formed by turbines or electric motors geared to the shafting and situated aft.

8.1.2 Unless otherwise advised, it is the responsibility of the Shipbuilder as the main contractor to ensure, in co-operation with the Engine builders, that the information required by this Section is prepared and submitted.

8.2 Basic system requirements

8.2.1 The systems are to be free from excessive torsional, axial and lateral vibration, and are to be aligned in accordance with tolerances agreed with the respective manufacturers.

8.2.2 Where changes are subsequently made to a dynamic system which has been approved, revised calculations are to be submitted for consideration.

8.3 Resilient mountings

8.3.1 Where the machinery is installed on resilient mountings, linear vibration (steady state and transient) is not to exceed the limiting values agreed with the manufacturers of the machinery nor those of the resilient mountings.

8.3.2 Misalignment arising from such vibration is not to impose excessive loading on machinery components within the system.

8.4 Torsional vibration

8.4.1 General

8.4.1.1 Torsional vibration calculations, including an analysis of the vibratory torques and stresses for the dynamic systems formed by the oil engines, turbines, motors, generators, flexible couplings, gearing, shafting and propeller, where applicable, including all branches, are to be submitted for approval together with the associated plans.

8.4.1.2 Particulars of the division of power developed throughout the speed range for turbines or from all intended combinations of operation in oil engine installations having more than one engine and/or with power take-off systems are to be submitted.

8.4.1.3 Any special speed requirements for prolonged periods in service are to be indicated, e.g., range of trawling revolutions per minute, range of operation revolutions per minute with a controllable pitch propeller, idling speed, etc.

8.4.1.4 The calculations and/or measurements carried out on oil engine installations containing transmission items sensitive to vibratory torque, e.g. gearing, flexible couplings, or generator rotors and their drives, are to take into account the effects of engine malfunction commonly experienced in service, such as cylinder(s) not firing.

8.4.1.5 Restricted speed ranges will be imposed in regions of speed where stresses are considered to be excessive for continuous running. Similar restrictions will be imposed, or other protective measures required to be taken, where vibratory torques are considered to be excessive for particular machinery items.

8.4.1.6 Where calculations indicate the possibility of excessive torsional vibration within the range of working speeds, torsional vibration measurements, using the appropriate recognized techniques, may be required to be taken from the machinery installation for the purpose of determining the need for restricted speed ranges.

8.4.2 Permissible limits of stresses due to torsional vibrations

8.4.2.1 Alternating torsional vibration stresses are stresses resulting from the alternating torque which is superimposed on the mean torque.

8.4.2.2 In no part of the propulsion system may the alternating torsional vibration stresses exceed the values of $\tau 1$ for continuous operation and $\tau 2$ for transient running.

8.4.2.3 For continuous operation the permissible stresses due to alternating torsional vibrations are not to exceed the following values:

$$\tau_1 = \pm \frac{\sigma B + 160}{18} C_k \, C_D \, (3 - 2\lambda^2) \text{ for } \lambda < 0.9$$

$$\tau_1 = \pm \frac{\sigma B + 160}{18} 1.38 \, C_k \, C_D \text{ for } 0.9 \le \lambda < 1.05$$

where,

τ_1 = permissible stress due to torsional vibrations for continuous operation [N/mm^2];

σB = tensile strength of shaft material [N/mm^2];

For calculation purposes, this value is not to be taken greater than:

- 600 [N/mm^2] for carbon and carbon manganese steels; and
- 800 [N/mm^2] for alloy steels;

C_k = factor for different shaft design features as given in Table 8.4.2;

C_D = size factor = 0.35 + 0.93d$^{-0.2}$;

d_o = shaft outside diameter under consideration [mm];

λ = speed ratio = n/n_o;

n = speed in rpm under consideration at rated power;

n_o = rated speed in rpm.

Table 8.4.2 : c_k factors for different design features										
Intermediate shafts with						**Thrust shafts external to engines**		**Tailshafts**		
Integral coupling flange and straight section	shrink fit couplings	Keyway, tapered connection	Keyway, cylindrical connection	Radial hole	Longitudinal slot[1]	On both sides of thrust collar	In way of bearing when a roller bearing is used	Flange mounted or keyless taper fitted propellers	Key fitted propellers	Between forward end of aft most bearing and forward stern tube seal
C_k = 1.0	1.0	0.60	0.45	0.50	0.30 [2)]	0.85	0.85	0.55	0.55	0.80

Note:

1) The c_k value is valid for 1, 2 and 3 slots and they are to be arranged 360, 180 or 120 degrees apart from each other respectively.
2) C_k = 0.3 is an approximation within the limitations given in Note No.6 under Table 6.5.1. More accurate estimate of the stress concentration factor (scf) may be determined from 6.2.3 c) or by direct application of FEM calculation. In which case:

$C_k = 1.45/\text{scf}$

The scf is defined as the ratio between the maximum local principal stress and √3 times the nominal torsional stress (determined for the bored shaft without slots).

8.4.2.4 Where a vessel, because of its type of employment, is operated predominantly in the lower speed range, special consideration may be given to the permissible stresses for continuous operation.

8.4.2.5 Where the stresses exceed the limiting values of τ_1 for continuous operation, restricted speed ranges are to be imposed which are only allowed to be passed through rapidly. Cl.4.12.6.1 may also be referred for barred speed range requirements.

8.4.2.6 Restricted speed ranges are not acceptable, in the speed range between 0.8 to 1.05 of the rated speed. The limits of the barred speed range are to be calculated in accordance with the following formula unless proved to be otherwise.

$$\frac{16\mathrm{N}_c}{18-\lambda} \le n \le \frac{(18-\lambda)\mathrm{N}_c}{16}$$

where,

n_c = critical speed in [rpm].

8.4.2.7 For transient running the permissible stresses due to the alternating torsional vibrations are not, in any case, to exceed the values given by the following formula:

$$\tau_2 = \frac{1.7\,\tau_1}{\sqrt{\mathrm{C_k}}}\ \text{for}\ \lambda \le 0.8$$

where,

τ_2 = permissible stress due to torsional vibrations for transient running.

8.5 Axial vibrations

8.5.1 For all main propulsion shafting systems, the Shipbuilders are to ensure that amplitudes due to axial vibrations are satisfactory throughout the speed range, so far as practicable. Where appropriate, amplitudes may be reduced by the use of suitable vibration dampers or phasing of propeller and engine, etc.

8.5.2 Unless previous experience of similar installation shows it to be unnecessary, calculations of the shafting system are to be carried out. These calculations are to include the effect of the thrust block seating and the surrounding hull structure taking part in the vibration. The result of these calculations or the evidence of previous experience is to be submitted for consideration.

8.5.3 Where calculations indicate the possibility of excessive axial vibration amplitudes within the range of working speeds, measurements using an appropriate recognized technique may be required to be taken from the shafting systems for the purpose of determining the need for restricted speed ranges.

8.6 Lateral vibrations

8.6.1 For all main propulsion shafting systems, the Shipbuilders are to ensure that amplitudes due to lateral vibrations are satisfactory throughout the speed range.

8.6.2 Unless previous experience of similar installations shows it to be unnecessary, calculations of lateral, or bending, vibration characteristics of the shafting system are to be carried out. These calculations, taking account of dynamic bearing stiffnesses, are to cover the frequencies giving rise to all critical speeds which may result in significant amplitudes within the speed range, and are to indicate relative deflections and bending moments throughout the shafting system.

8.6.3 The results of these calculations, or the evidence of previous experience, is to be submitted for consideration.

8.6.4 Where calculations indicate the possibility of excessive lateral vibration amplitudes within the range of working speeds, measurements using an appropriate recognized technique may be required to be taken from the shafting system for the purpose of determining the need for restricted speed ranges.

8.7 Shaft alignment

8.7.1 For main propulsion installations, the shafting is to be aligned to give reasonable bearing reactions, and bending moments, taking into consideration following factors :

- Forces which may affect the reliability of the propulsion shafting system including weight of the propeller and shafts,

- Hydrodynamic forces acting on the propeller,

- Number of propeller blades in relation to diesel engine cylinders,

- Misalignment forces,

- Thermal expansion,

- Flexibility of engine and thrust bearing foundations,

- Engine induced vibrations, gear tooth loadings, flexible couplings,

- Effect of power take-off,

- Effect of hull deformations at all conditions of ship loading and operation.

Consideration is also to be given to any limits of vibrations and loadings specified by the equipment manufacturer. The Shipbuilder is to position the bearings and construct the bearing seatings to minimize the effects of movements under all operating conditions.

8.7.2 For geared installations, where two or more pinions are driving the final reduction wheel, calculations are to be submitted to verify that shaft alignment is such that proper bearing reactions are maintained under all operating conditions.

8.7.3 Shaft alignment calculations are to be submitted for the following alignment-sensitive types of installations for review:

i) Propulsion shafting with power take-off or with booster power arrangements.
ii) Propulsion shafting for which the tail shaft bearings are to be slope bored.
iii) Propulsion shaft having diameter 300mm. and above in way of after most stern tube bearing
iv) Propulsion shafting arrangement requiring long shaft line.

The alignment calculations are to include bearing reactions, shear forces and bending moments along the shafting.

The alignment calculations are to be performed for the following conditions, as applicable:

- Theoretically aligned cold and hot conditions of the shaft with specified alignment tolerances.

- Deviation from the theoretical aligned conditions due to the forces exerted by power take-off or booster power.

Calculations are to be performed for the maximum allowable alignment tolerances and are to show that:

- Bearing loads under all operating conditions are within the acceptable limits specified by the bearing manufacturer.
- Bearing reactions are always positive (i.e. supporting the shaft).
- Shear forces and bending moments on the shaft are within acceptable limits in association with other stresses in the shaft.
- Forces and moments on propulsion equipment are within the limits specified by the machinery manufacturers.

8.7.4 Shaft alignment is to be verified by measurement.

Section 9

Thrusters

9.1 Scope

9.1.1 The requirements of this section are applicable to:

- fixed thruster for propulsion
- steerable thruster units (azimuth thrusters) for propulsion and steering
- tunnel thruster for transverse propulsion aid to manoeuvring.

9.2 Plans and particulars

The following plans and information in triplicate are to be submitted.

9.2.1 Fixed/azimuth propulsion thrusters

a) A general arrangement sectional assembly plan showing all the connections of the torque transmitting components from the prime mover to the propeller, together with the azimuthing mechanism and if a nozzle is provided, the nozzle ring structure and nozzle support struts.

b) Detailed and dimensional plans of the individual torque transmitting components.

c) Schematic plans for lubricating and hydraulic systems, together with pipe material, relief valves and working pressures.

9.2.2 Tunnel thrusters

In addition to applicable requirements of 9.2.1, structural assembly plan including connections to tunnel.

9.2.3 Calculations and specifications

a) Thruster prime mover type and operational power/speed envelop.

b) Rating and type of motor for the azimuthing mechanism (e.g. type hydraulic or electric).

c) Gearing calculations for the azimuthing and propulsion mechanism which is to be designed in accordance with classification notes on the design of gearing. Calculation for bevel gears is to be on the basis of a conversion to equivalent helical gear.

d) Bearing specifications.

e) Details of control engineering aspects in accordance with Chapter 7.

f) Calculations indicating suitability of components for short term high power operation, where applicable.

g) Where design is carried out using fatigue analysis, a fatigue strength analysis of components indicating a factor of safety of 1.5 at the design loads based on a suitable fatigue failure criteria is required to be submitted for review.

9.3 Materials

9.3.1 The materials used on the construction are to be manufactured and tested in accordance with Part 2.

9.3.2 The grades for various components to be analogous to relevant section of the Rules, Pt.4, Ch.4, Sec.7 for propellers, Pt.4, Ch.4, Sec.6 for shafting and Pt.4, Ch.4, Sec.5 for gearing.

9.4 Design and construction

9.4.1 General

9.4.1.1 The arrangement of all types of thrusters is to be such that the craft can be manoeuvred in accordance with the design specifications.

9.4.1.2 The requirements associated with the structural and watertight integrity and the installation arrangement are to be in accordance with Pt.3.

9.4.1.3 In addition to the requirements of this section reference is to be made to:

- Main transmission gearing (Pt.4, Ch.4, Sec.5). Bevel gears will be specially considered on the basis of a conversion to equivalent helical gears.
- Main transmission shafting (Pt.4, Ch.4, Sec.6).
- Propeller (Pt.4, Sec.7).
- Torsional vibration (Pt.4, Ch.4, Sec.8 of the 'Rules and Regulations for the Construction and Classification of Steel Ships').
- Lateral vibration for shafting systems which include cardan shafts (Pt.4, Ch.4, Sec.8 of the 'Rules and Regulations for the Construction and Classification of Steel Ships').

9.4.2 Azimuth thrusters

9.4.2.1 The following requirements are to be complied with:

a) The azimuthing mechanism is to be capable of a maximum rotational speed of not less than 1.5 rev/min.

b) Gearing for the azimuthing mechanism is to be designed in accordance with classification notes on the design of gearing. Bevel gears will be specially considered on the basis of a conversion to equivalent helical gears.

i) Under dynamic operating conditions, the gear is to be considered for:

- Design maximum dynamic duty steering torque.
- Variable loading, where applicable. A spectrum (duty) factor may be used. The load spectrum value is to be derived using load measurements of similar units, where possible.

ii) Under a static duty (< 10^3 load cycles) steering torque. (for azimuth thruster with nozzle see 9.4.3.1).

iii) The following minimum factor of safety values are to be achieved:

Surface stress S_{Hmin} = 1.2

Bending Stress S_{Fmin} = 1.55.

c) For hydraulic pressure retaining parts and load bearing (See Chapter 5).

9.4.3 Azimuth thrusters with a nozzle

9.4.3.1 For steerable rudder propellers contained within a nozzle, the design lateral force Fr and the turning moment Q_r is to be calculated as follows:

$$F_r = 376 . A . V^2 \quad [N]$$

$$Q_r = F_r . r \quad [N\text{-}m]$$

where,

A = projected area of nozzle [M^2]

V = Maximum service speed [knots] with the ship on summer load waterline. When the speed is less than 10 knots, V is to be replaced by the expression V_{min} = (V+20)/3

r = the horizontal distance from centre line of stock to centre of pressure of nozzle, but not to be taken less than 10% of the chord length of the nozzle.

The nozzle stock diameter in way of tiller, is to be not less than:

$$d_u = 4.2\sqrt[3]{Q_r.K} \quad [mm]$$

where,

k = material factor for nozzle stock.

9.4.3.2 The scantlings of the nozzle stock or steering tube are to be such that the equivalent stress, σ,does not exceed 118/k [N/mm^2] i.e.

$$\sigma_e = \sqrt{\sigma^2 + 3\tau_t^2} \leq 118 / k \ [N/mm^2]$$

where,

σ is the bending stress [N/mm^2] calculated using the maximum bending moment, BM, on the nozzle stock or steering tube.

For nozzles without bottom support :

$$BM = \sqrt{F_r^2 + T^2} \text{ x a [Nm]}$$

T = Maximum thrust developed by the thruster [N]

F_r = design lateral force [N/mm^2] as per 9.4.3.1

a = Vertical distance from centre line of nozzle to the section under consideration [m] (See Fig.9.4.3.2).

τ_t is the torsional shear stress [N/mm^2] calculated using the torque Qr as per 9.4.3.1.

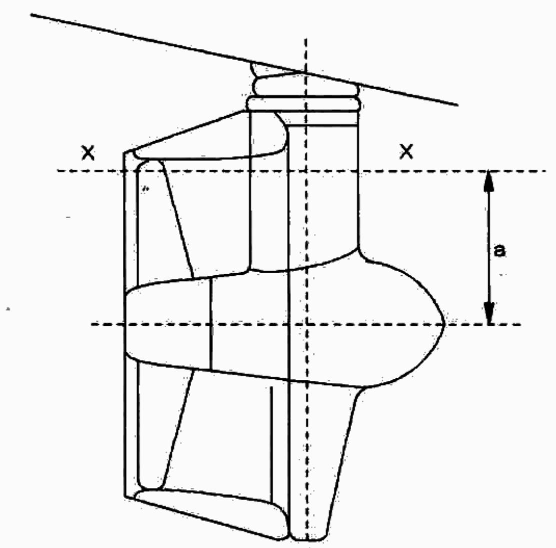


Fig.9.4.3.2 : Azimuth thrusters

9.5 Piping systems

9.5.1 General

The piping system for azimuth thrusters is to comply with the general design requirements given in Pt.4, Ch.2.

The specific requirements for lubricating/ hydraulic oil systems and standby arrangements are given in Pt.4, Ch.3.

9.5.2 Azimuth thruster

The hydraulic power operating systems for each azimuth thruster are to be provided with the following:

a) Arrangements to maintain the cleanliness of the hydraulic fluid, taking into consideration the type and design of the hydraulic system.

b) A fixed storage tank having sufficient capacity to recharge at least one azimuth power actuating system including the reservoir. The piping from the storage tank is to be permanent and arranged in such a manner as to allow recharging from within the thruster space.

c) Where the lubricating oil for the azimuth thrusters is circulated under pressure, provision is to be made for the efficient filtration of the oil. The filters are to be capable of being cleaned without stopping the thruster or reducing the supply of filtered oil.

9.6 Control and monitoring

9.6.1 General

9.6.1.1 Except where indicated in this section the control engineering systems are to be in accordance with Pt.4, Ch.7.

9.6.1.2 Azimuthing control for azimuth thruster(s) and propeller pitch control for azimuth and/or tunnel thruster(s) are to be provided from the navigating bridge, the main machinery control location and locally.

9.6.1.3 Means are to be provided at the remote control location(s) to stop each azimuth or tunnel thruster unit.

9.6.2 Monitoring and alarms

9.6.2.1 Alarms and monitoring requirements are indicated in 9.6.2.2, 9.6.2.3 and Table 9.6.2.

9.6.2.2 An indication of the angular position of the azimuth thruster(s) and the propeller pitch position for azimuth and/or tunnel thruster(s) are to be provided at each location from which it is possible to control the direction of thrust or the pitch.

9.6.2.3 All alarms associated with thruster unit faults are to be indicated individually on the navigating bridge and in accordance with the alarm system specified by Chapter 7.

Table 9.6.2

Item	Alarm	Note
Thruster, azimuth or tunnel		Indicators, see 9.6.2.2
Azimuthing motor	Power failure, single phase	Also running indication on bridge and at machinery control location
Propeller pitch motor	Power failure	In case of failure the propeller pitch should be locked in full ahead position. Also running indication on bridge and at machinery control location
Electric propulsion motor	Overload, power failure	Also running indication on bridge and at machinery control location
Control system	Failure	
Hydraulic oil supply tank level	Low	
Hydraulic oil system pressure	Low	
Hydraulic oil system temperature	High	Where oil cooler is fitted
Hydraulic oil filters differential pressure	High	Where oil filters are fitted
Lubricating oil supply pressure	Low	If separate forced lubrication

9.7 Electrical systems

9.7.1 General

The electrical installation is to be designed, constructed and installed in accordance with the requirements of Pt.4, Ch.8.

9.7.2 Emergency power for steering systems and drives

The arrangement to comply with Pt.4, Ch.6, Sec.6, Cl.6.1.1

9.7.3 Circuits

Azimuth thruster auxiliaries and controls are to be served by individual circuits. Services that are duplicated are to be separated throughout their length as widely as is practicable and without the use of common feeders, transformers, converters, protective devices or control circuits.

9.8 Tests

9.8.1 Azimuth thrusters

9.8.1.1 The performance specified for the craft is to be demonstrated.

9.8.1.2 The actual values of steering torque are to be verified during sea trials to confirm that the design maximum dynamic duty torque has not been exceeded.

9.8.2 Tunnel thrusters

It is to be demonstrated that the thruster unit meets the specified performance.

End of Chapter

Chapter 5

Boilers and Pressure Vessels

Contents

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to pressure vessels of seamless and fusion welded construction, and their mountings and fittings, for the following uses :

a) Fired boilers;

b) Exhaust gas heated boilers;

c) Economizers, superheaters, reheaters and steam receivers for, and associated with (a) and(b);

d) Steam heated steam generators;

e) Other pressure vessels containing:

- toxic fluids;
- fluids with pressure above 40 bar; and
- vapours or gases, e.g. air receivers, hydrophore or similar vessels, CO_2 containers, etc. and having $pV \geq 1.5$, where p is the design pressure in bar and V is the volume of the vessel [m^3].

1.1.2 Consideration will be given to arrangements or details of boilers, pressure vessels and equipment which can be shown to comply with other recognized standards, provided they are not less effective.

1.2 Design pressure

1.2.1 The design pressure is the maximum permissible working pressure and is to be not less than the highest set pressure of any safety valve.

1.2.2 The calculations made to determine the scantlings of the pressure parts are to be based on the design pressure, adjusted where necessary to take account of pressure variations corresponding to the most severe operational conditions.

1.2.3 It is desirable that there should be a margin between the normal pressure at which the boiler or pressure vessel operates and the lowest pressure at which any safety valve is set to lift, to prevent unnecessary lifting of the safety valve.

1.3 Metal temperature

1.3.1 The metal temperature, T, used to evaluate the allowable stress, σ, is to be taken as the actual metal temperature expected under operating conditions for the pressure part concerned, and is to be stated by the manufacturer when plans of the pressure parts are submitted for consideration.

1.3.2 For boilers, the design metal temperature is not to be taken less than the following values, unless justified by an exact calculation of the temperature drop and is in no case to be taken less than 250°C:

a) For steam heated steam generators, secondary drums of double evaporation boilers, steam receivers and pressure parts of fired pressure vessels not heated by hot gases and adequately protected by insulation, the metal temperature, T is to be taken as the maximum temperature of the internal fluid;

b) For pressure parts heated by hot gases, T is to be taken as not less than 25°C in excess of the maximum temperature of the internal fluid;

c) For combustion chambers of the type used in horizontal wet-back boilers, T is to be taken as not less than 50°C in excess of the maximum temperature of the internal fluid;

d) For furnaces, fire boxes, rear-tube plates of dry-back boilers and pressure parts subject to similar rates of heat transfer, T is to be taken as not less than 90°C in excess of the maximum temperature of the internal fluid;

e) For boiler, superheater, reheater and economizer tubes, the design temperature is to be taken as under :

   i) For boiler tubes the design temperature is to be taken as not less than saturated steam temperature plus 25°C for tubes mainly subject to convection heat, or plus 50°C for tubes mainly subject to radiant heat;

   ii) For superheater and reheater tubes, the design temperature is to be taken as not less than steam temperature expected in the part being considered, plus 35°C for tubes mainly subject to convection heat. For tubes mainly subject to radiant heat the design temperature is to be taken as not less than the steam temperature expected in the part being considered, plus 50°C, but the actual metal temperature expected is to be stated when submitting plans;

   iii) The design temperature for economizer tubes is to be taken as not less than 35°C in excess of the maximum temperature of the internal fluid.

1.3.3 In general, any part of boiler drums or headers not protected by tubes, and exposed to radiation from the fire or to the impact of hot gases, is to be protected by a shield of good refractory material or by other approved means.

1.3.4 Drums and headers of thickness greater than 30 [mm] are not to be exposed to combustion gases having an anticipated temperature in excess of 650°C unless they are efficiently cooled by closely arranged tubes.

1.4 Plans and particulars

1.4.1 The following plans, in triplicate, for boiler and pressure vessels are to be submitted for approval, in so far as applicable:

a) General arrangement, including arrangement of valves and fittings;

b) Sectional assembly;

c) Seating arrangements;

d) Steam, water drum and header details;

e) Water wall details;

f) Steam and superheater tubing, including the tube support arrangements;

g) Economizer details;

h) Casing arrangement;

i) Reheat section;

j) Fuel oil burning arrangement;

k) Forced draft system;

l) Boiler mountings including steam stop valves, safety valves and their relieving capacities, feed water connections, blow-off arrangements, watergauges, test cocks, etc.

1.4.2 The plans are to include the following particulars, in so far as applicable :

a) Scantlings;

b) Materials;

c) Weld details;

d) Design pressures and temperatures;

e) Heating surface areas of boilers and superheaters;

f) Estimated pressure drop through superheater;

g) Estimated evaporation rate;

h) Proposed setting pressure of safety valves on steam drum and superheater;

i) Pressure vessel class;

j) Details of heat treatment and testing of welds;

k) Calculations of thicknesses, when required;

l) Test pressures.

1.5 Classification of pressure vessels

1.5.1 For Rule purposes, boilers and pressure vessels are graded as shown in Table 1.5.1.

1.5.2 Pressure vessels which are constructed in accordance with the requirements of Class 2 or Class 3 will, if manufactured in accordance with the requirements of a superior class, be approved with the scantlings appropriate to that class.

1.5.3 In special circumstances relating to service conditions, materials, operating temperature, the carriage of dangerous gases and liquids, etc., it may be required that certain pressure vessels be manufactured in accordance with the requirements of a superior class.

1.6 Definition of symbols

1.6.1 The symbols used in the various formulae in this Chapter are defined as follows and are applicable to the specific part of the pressure under consideration :

d = diameter of hole or opening [mm];

D_i = inside diameter [mm];

D_o = outside diameter [mm];

J = joint factor applicable to the welded seams or ligament efficiency between tube holes, expressed as a fraction;

p = design pressure, in bar;

R_i = inside radius [mm];

R_o = outside radius [mm];

r_o = outside knuckle radius [mm];

r_i = inside knuckle radius [mm];

s = pitch [mm];

T = design temperature, °C;

t = minimum thickness [mm];

σ = allowable stress [N/mm^2].

1.7 Materials

1.7.1 Materials used in the construction of Class 1 & 2 pressure vessels are to be manufactured and tested in accordance with the requirements of Pt.2 under the supervision of IRS Surveyors.

Materials for Class 3 pressure vessels will be accepted with manufacturer's certificate.

Table 1.5.1 : Grading of pressure vessels

	Boilers	Steam-heated steam generators	Other pressure vessels
Class 1	p > 3.5	$p > \frac{15000}{D_i + 1000}$	p > 50 or t > 38
Class 2	p ≤ 3.5	$p \le \frac{15000}{D_i + 1000}$	$\frac{20000}{D_i + 1000} < p \le 50$ or $16 < t \le 38$ or material temperature > 150°C
Class 3			Pressure vessels not included in Class 1 and 2

Note:

p = design pressure, in bar; D_i = internal diameter [mm]; t = shell thickness [mm]

Valves and fittings for pressure vessels are to be manufactured and tested under the supervision of IRS Surveyors in the following cases:

- cast steel and nodular cast iron valves and fittings - when D > 50 [mm] and PD > 2000
- cast steel valves and fittings - when D > 50 [mm] and T > 400°C or T < -10°C
- copper alloy valve and fittings - when D >50 [mm] and pD > 1000
- Where p is the design pressure in bar and D is the nominal diameter in [mm].

1.7.2 The specified minimum tensile strength of carbon and carbon manganese steel plates, pipes, forgings and castings is to be within the following general limits :

a) For seamless and fusion welded pressure vessels - 340 - 520 [N/mm^2];

b) For boiler furnaces, combustion chambers and flanged plates - 400 - 520 [N/mm^2].

1.7.3 The specified minimum tensile strength of low alloy steel plates, pipes, forgings and castings is to be within the general limits of 400 - 500 [N/mm^2], and pressure vessels made in these steels are to be either seamless or Class 1 fusion welded.

1.7.4 The specified minimum tensile strength of boiler and superheater tubes is to be within the following general limits :

a) Carbon and carbon-manganese steels - 320 - 460 [N/mm^2];

b) Low alloy steels - 400 - 500 [N/mm^2].

1.7.5 Semi-killed, fully killed and fine grain, normal strength structural steels complying with the requirements of Pt.2, Ch.3 will be accepted for following Class 3 pressure vessels when:

$$p < \frac{15000}{D_i + 2000}$$

1.7.6 Where it is proposed to use materials other than those specified in Pt.2, details of the chemical compositions, heat treatment and mechanical properties are to be submitted for approval. In such cases the values of the mechanical properties used for deriving the allowable stress are to be subject to agreement by IRS.

1.7.7 Where a fusion welded pressure vessel is to be made of alloy steel and approval of the scantlings is required on the basis of the high temperature properties of the material, particulars of the welding consumables to be used, including typical mechanical properties and chemical composition of the deposited weld metal, are to be submitted for approval.

1.8 Allowable stress

1.8.1 The term "allowable stress",σ, is the stress to be used in the formulae for calculation of scantlings of pressure parts.

1.8.2 The allowable stress, σ, is to be the lowest of the following values:

$$= \frac{E_t}{1.6} \text{ or } \frac{E_{20}}{1.8} \text{ or } \frac{R_{20}}{2.7} \text{ or } \frac{S_R}{1.6}$$

where,

E_t = specified minimum lower yield strength or 0.2 per cent proof stress at temperature T;

E_{20} = specified minimum lower yield strength or 0.2 per cent proof stress at ambient temperature;

R_{20} = specified minimum tensile strength at room temperature;

S_R = average stress to produce rupture in 100,000 hours at temperature T;

T = metal temperature (see 1.6).

1.8.3 The allowable stress for steel castings is to be taken as 80 per cent of the value determined by the method indicated in 1.8.2, using the appropriate values for cast steel.

1.8.4 Where steel castings, which have been tested in accordance with Pt.2, are also subjected to non-destructive tests, consideration will be given to increasing the allowable stress using a factor up to 90 per cent in lieu of the 80 per cent referred to in 1.8.3. Particulars of the non-destructive test proposals are to be submitted for consideration.

1.9 Joint factors

1.9.1 The following joint factors are to be used in equations in this chapter, where applicable. Fusion welded pressure parts are to be made in accordance with Ch.10 :

Pressure vessel	Joint factor
Class 1	1.0
Class 2	0.80
Class 3	0.60

1.9.2 The longitudinal joints for all classes of vessels are to be butt joints. Circumferential joints for Classes 1 and 2 vessels are also to be butt joints.

1.10 Pressure parts of irregular shape

1.10.1 Where pressure parts are of such irregular shape that it is impracticable to design their scantlings by the application of formulae given in this Chapter, the suitability of their construction is to be determined by hydraulic proof test of a prototype or by an agreed alternative method.

1.11 Adverse working conditions

1.11.1 Where working conditions are adverse, special consideration may be required to be given to increasing the scantlings derived from the formulae, e.g. by increasing the corrosion or other allowance at present shown in the formulae, or by adopting a design pressure higher than defined in 1.2, to offset the possible reduction of life in service caused by the adverse conditions. In this connection, where necessary, account should also be taken of any excess of loading resulting from :

a) impact loads, including rapidly fluctuating pressures;

b) weight of the vessel and normal contents under operating and test conditions;

c) superimposed loads such as other pressure vessels, operating equipment, insulation, corrosion-resistant or erosion-resistant linings and piping;

d) reactions of supporting lugs, rings, saddles or other types of supports; or

e) the effect of temperature gradients on maximum stress.

1.12 Minimum shell thickness

1.12.1 Only plus tolerances are allowed on the design shell thickness.

1.12.2 The thickness after forming of any shell or head is not to be less than $3+\frac{D_i}{1500}$ [mm] for carbon, carbon-manganese and low-alloy steels or 3 [mm] for stainless steel and non-ferrous materials. For pressure vessels, where the cylindrical part is made of a pipe, a smaller minimum thickness may be approved. See also Sec.2 for minimum thicknesses of plates in case of boilers.

1.13 Heat treatment, non-destructive examination and routine tests

1.13.1 Details regarding heat treatment, non-destructive examination and routine tests are to be in accordance with the requirements of Ch.10.

Section 2

Design Requirements

2.1 Cylindrical shells and drums subject to internal pressure

2.1.1 Minimum thickness

2.1.1.1 The minimum thickness, t, of a cylindrical shell is to be determined by the following formula:

$$t = \frac{p\,R_i}{10\sigma J - 0.5p} + 0.75 \text{ [mm]}$$

where,

t, p, R_i and σ are defined in Sec.1;

J = efficiency of ligaments between tube holes or other openings in the shell or the joint factor of the longitudinal joints (expressed as a fraction), as defined in Sec.1, whichever applies. In the case of seamless shells clear of tube holes or other openings, J = 1.0.

2.1.1.2 The formula in 2.1.1.1 is applicable only where the resulting thickness does not exceed half the internal radius, i.e. where R_o is not greater than 1.5 R_i.

2.1.1.3 Irrespective of the thickness determined by 2.1.1.1, t is not to be less than:

For Boilers (Fired and exhaust gas heated), economizers, superheaters, reheaters, steam receivers, steam-heated steam generators and similar vessels	6.0 [mm] for cylindrical shell plates. For tube plates, such thickness as will give a minimum parallel seat of 9.5 [mm], or such greater width as may be necessary to ensure tube tightness.

2.1.2 Efficiency of ligaments between tube holes

2.1.2.1 Where tube holes are drilled in a cylindrical shell in a line or lines parallel to its axis, the efficiency, J, of the ligaments is to be determined as follows:

a) for regular drilling (See Fig.2.1.2.1)

$$J = \frac{s - d}{s}$$

b) for irregular drilling (See Fig.2.1.2.2)

$$J = \frac{S_1 + S_2 - 2d}{S_1 + S_2}$$

where,

d = the mean effective diameter of the tube holes, [mm], after allowing for any serrations, counterboring of recessing, or the compensating effect of tube stub, see 2.1.3 and 2.1.4;

s = pitch of tube holes [mm];

s_1 = the shorter of any two adjacent pitches [mm];

s_2 = the longer of any two adjacent pitches [mm].

2.1.2.2 When applying the formula in 2.1.2.1, the double pitch (s_1 + s_2) chosen is to be that which makes J a minimum, and in no case is s_2 to be taken as greater than twice s_1.

2.1.2.3 Where the circumferential pitch between tube holes measured on the mean of the external and internal drum or header diameters is such that the ligament efficiency determined by the formula in 2.1.2.1 is less than one- half of the ligament efficiency of the longitudinal axis, J is to be taken as twice the circumferential efficiency.

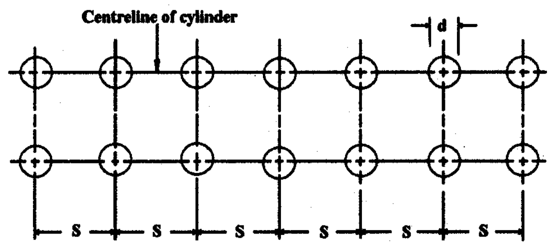


Fig. 2.1.2.1 : Regular drilling

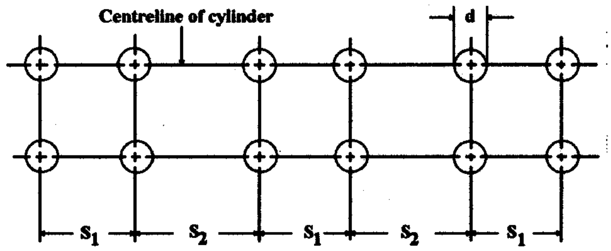


Fig. 2.1.2.2 : Irregular drilling

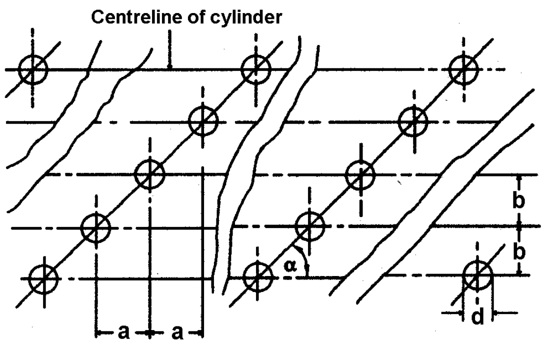


Fig. 2.1.2.3 : Spacing of holes on a diagonal line

2.1.2.4 Where tube holes are drilled in a cylindrical shell along a diagonal line with respect to the longitudinal axis, the efficiency, J, of the ligament is to be determined as in 2.1.2.5 to 2.1.2.8.

2.1.2.5 For spacing of tube holes on a diagonal line as shown in Fig.2.1.2.3, or in a regular saw-tooth pattern as shown in Fig.2.1.2.4, J is to be obtained from the series of curves given in Fig 2.1.2.6 where a and b, as shown in Fig.2.1.2.3 and Fig.2.1.2.4, are measured, in millimeters, on the median line of the plate , and d is as defined in 2.1.2.1.

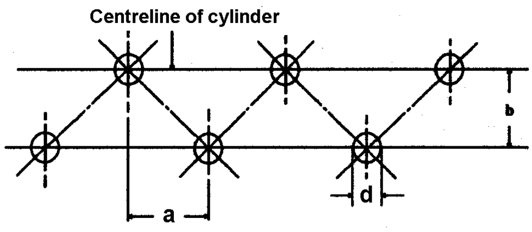


Fig. 2.1.2.4 : Regular saw-tooth pattern of holes

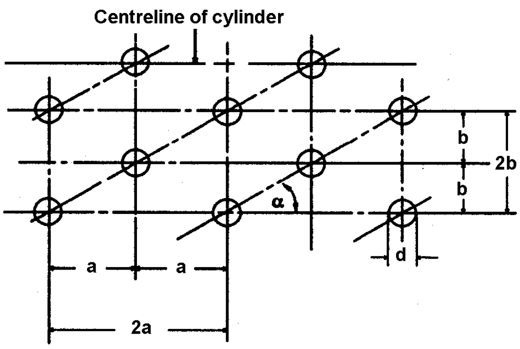


Fig. 2.1.2..5 : Regular staggering of holes

2.1.2.6 The data for Fig.2.1.2.6 is based on the following:

$$J = \frac{2}{A + B + \sqrt{(A - B)^2 + 4C^2}}$$

where,

$$A = \frac{a\,(\mathrm{Cos}^2\,\alpha + 1)}{2\,(a - d\,Cos\alpha)}$$

$$B = 0.5\left(1 - \frac{\mathrm{d\,Cos}\alpha}{a}\right)\left(\mathrm{Sin}^2\alpha + 1\right)$$

$$C = \frac{a\,\mathrm{Sin}\alpha\,Cos\alpha}{2\,(a - d\,Cos\alpha)}$$

$$\mathrm{Cos}\alpha = \frac{a}{\sqrt{a^2 + b^2}}$$

$$\mathrm{Sin}\alpha = \frac{b}{\sqrt{a^2 + b^2}}$$

α = angle between centerline of cylinder and centerline of diagonal holes.

2.1.2.7 For regularly staggered spacing of tube holes as shown in Fig.2.1.2.5, the smallest value of the efficiency, J, of all ligaments (longitudinal, circumferential and diagonal) is obtained from Fig.2.1.2.7, where a and b, as shown in Fig.2.1.2.5 are measured, in millimeters, on the median line of the plate, and d as defined in 2.1.2.1.

2.1.2.8 For irregularly spaced tube holes whose centers do not lie on a straight line, the formula 'b' in 2.1.2.1 is to apply, except that an equivalent longitudinal width is to be used. An equivalent longitudinal width is that which gives, using the formula 'a' in 2.1.2.1 the same efficiency as would be obtained using Fig.2.1.2.6 for the diagonal ligament in question.

2.1.2.9 The spacing of tube holes is to be such that the minimum width, in [mm], of any ligament between tube holes is not less than:

$$0.125\ d + 12.5\ [mm]$$

where,

d = diameter of tube holes [mm].

2.1.3 Compensating effect of tube stubs

2.1.3.1 Where a drum or header is drilled for tube stubs fitted by strength welding, either in line or in staggered formation, the effective diameter of holes is to be taken as follows:

$$d_e = d_a - \frac{A}{t}$$

where,

d_e = the equivalent diameter of the hole [mm];

d_a = the actual diameter of the hole [mm];

A =the compensating area provided by each tube stub and its welding fillets [mm^2];

t = thickness of the shell [mm].

2.1.3.2 The compensating area, A, is to be measured in a plane through the axis of the tube stub parallel to the longitudinal axis of the drum or header and is to be calculated as follows (See Fig.2.1.3.1 and Fig.2.1.3.2):

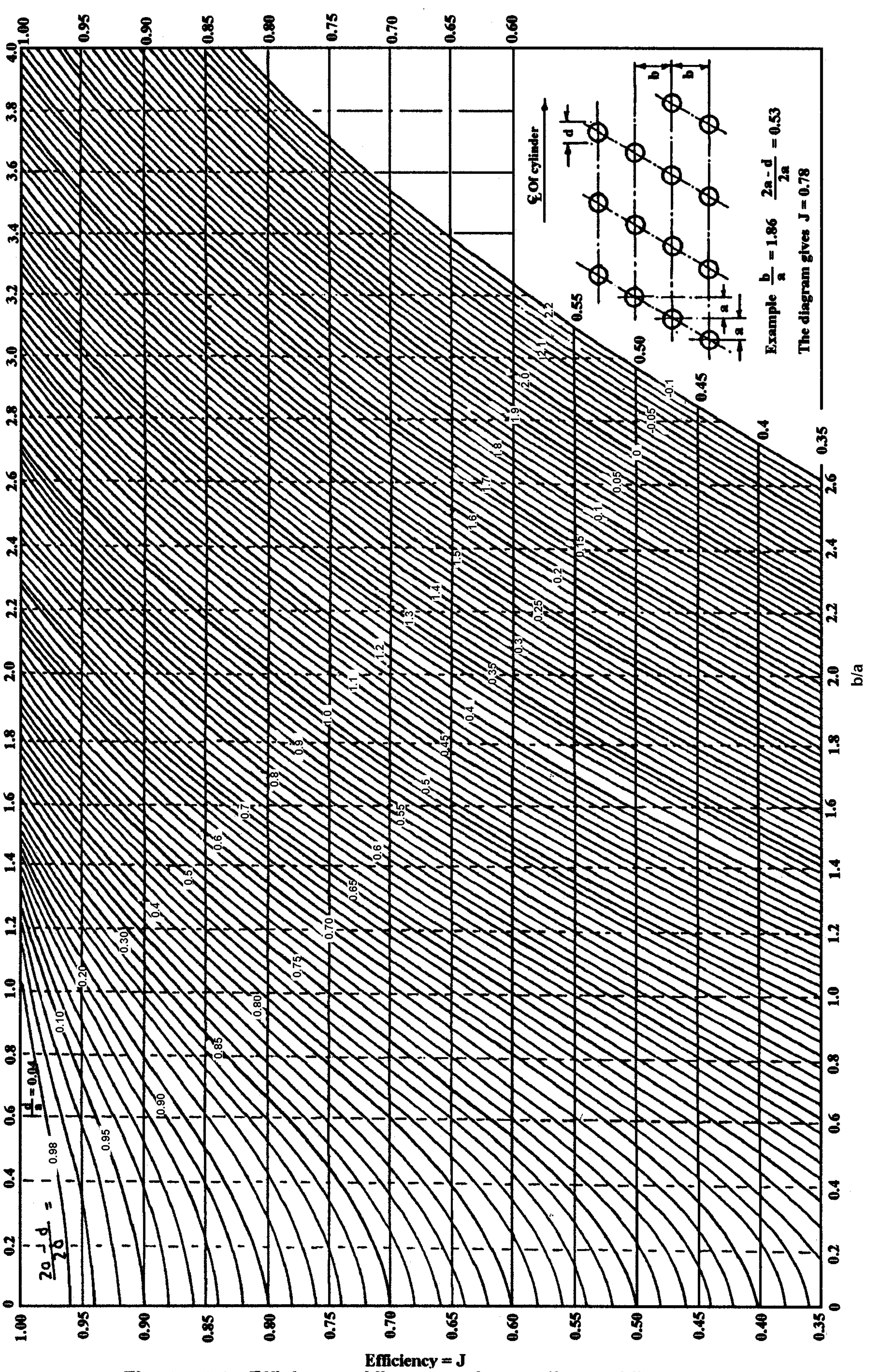


Fig. 2.1.2.6 : Efficiency of ligament along a diagonal line

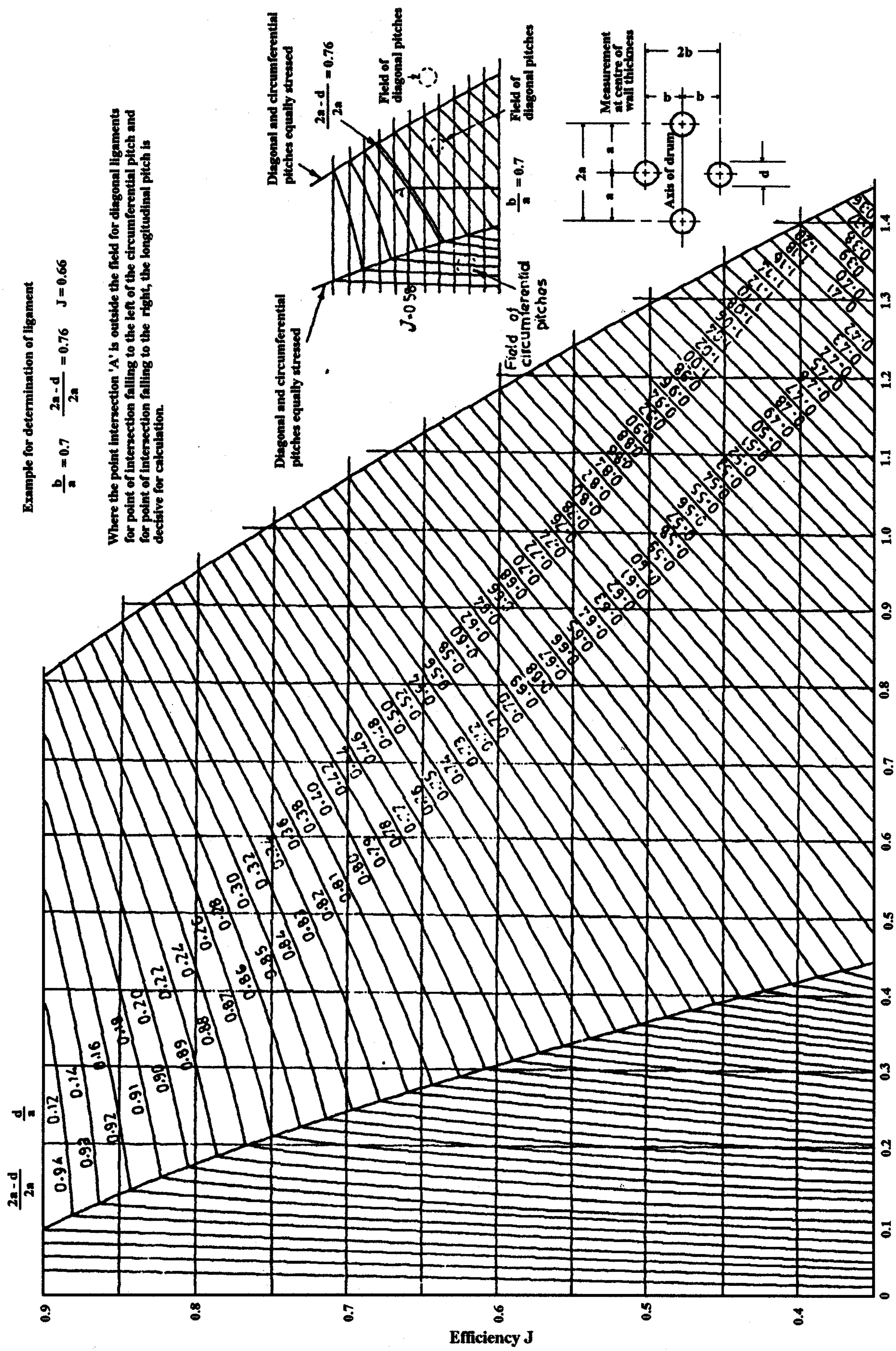
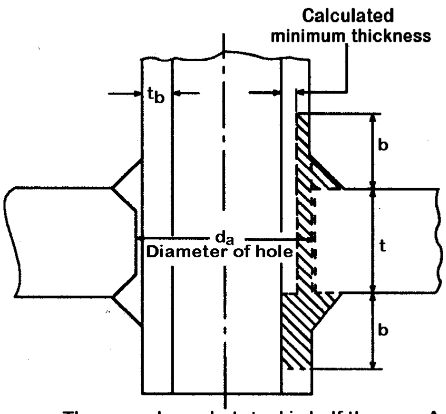
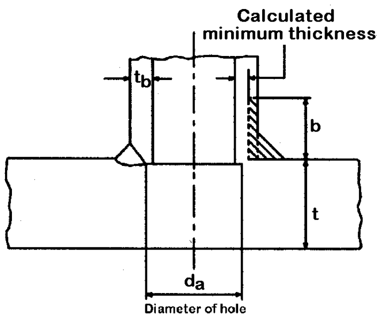


Fig. 2.1.2.7 : Efficiency of ligaments between holes



The area shown hatched is half the area A

Fig. 2.1.3.1 : Compensation of welded tube stubs



The area hatched is half the area A

Fig. 2.1.3.2 : Compensation of welded tube stubs

- The cross-sectional area of the stub, in excess of that required by 2.7.1 for the minimum tube thickness, from the interior surface of the shell up to a distance b from the outer surface of the shell;

- plus the cross-sectional area of the stub projecting inside the shell within a distance b from the inner surface of the shell;

- plus the cross-sectional area of the shell welding fillets inside and outside the shell;

where,

$$b = \sqrt{d_a \; t_b}$$

t_b = actual thickness of tube stub [mm].

2.1.3.3 Where the material of the tube stub has an allowable stress lower than that of the shell, the compensating cross-sectional area of the stub is to be multiplied by the ratio:-

$$\frac{\text{allowable stress of stub at design metal temperature}}{\text{allowable stress of shell at desgn metal temperature}}$$

2.1.3.4 No credit will be given for the additional strength of tube stub material having an allowable stress greater than that of the shell.

2.1.4 Unreinforced openings

2.1.4.1 Openings in a definite pattern such as tube holes, may be designed in accordance with the rules for ligaments in 2.1.2, provided that the diameter of the largest hole in group does not exceed that permitted by 2.1.4.2.

2.1.4.2 The maximum diameter, d, of any isolated unreinforced openings is to be obtained from the curves in Fig.2.1.4.1 and Fig.2.1.4.2. The value of K to be used is calculated from the following formula:

$$K = \frac{p\,D_o}{18.2\,\sigma\,t}$$

where,

p, D_o and σ are defined in Sec.1;

t = actual thickness of shell [mm].

2.1.4.3 For elliptical or oval holes, d refers to the major axis when this lies longitudinally or to the mean of the major and minor axes when minor axis lies longitudinally.

2.1.4.4 No unreinforced opening is to exceed 200 [mm] in diameter.

2.1.4.5 Openings may be considered isolated if the center distance between two openings on the longitudinal axis of the cylindrical shell is not less than:

$d+1.1\sqrt{Dt}$ with a minimum of 5d

where,

d = diameter of openings in shell (mean diameter if dissimilarly sized openings are involved)

D = mean diameter of shell

t = actual thickness of shell

Where the center distance is less than so derived, the openings are to be fully compensated

.

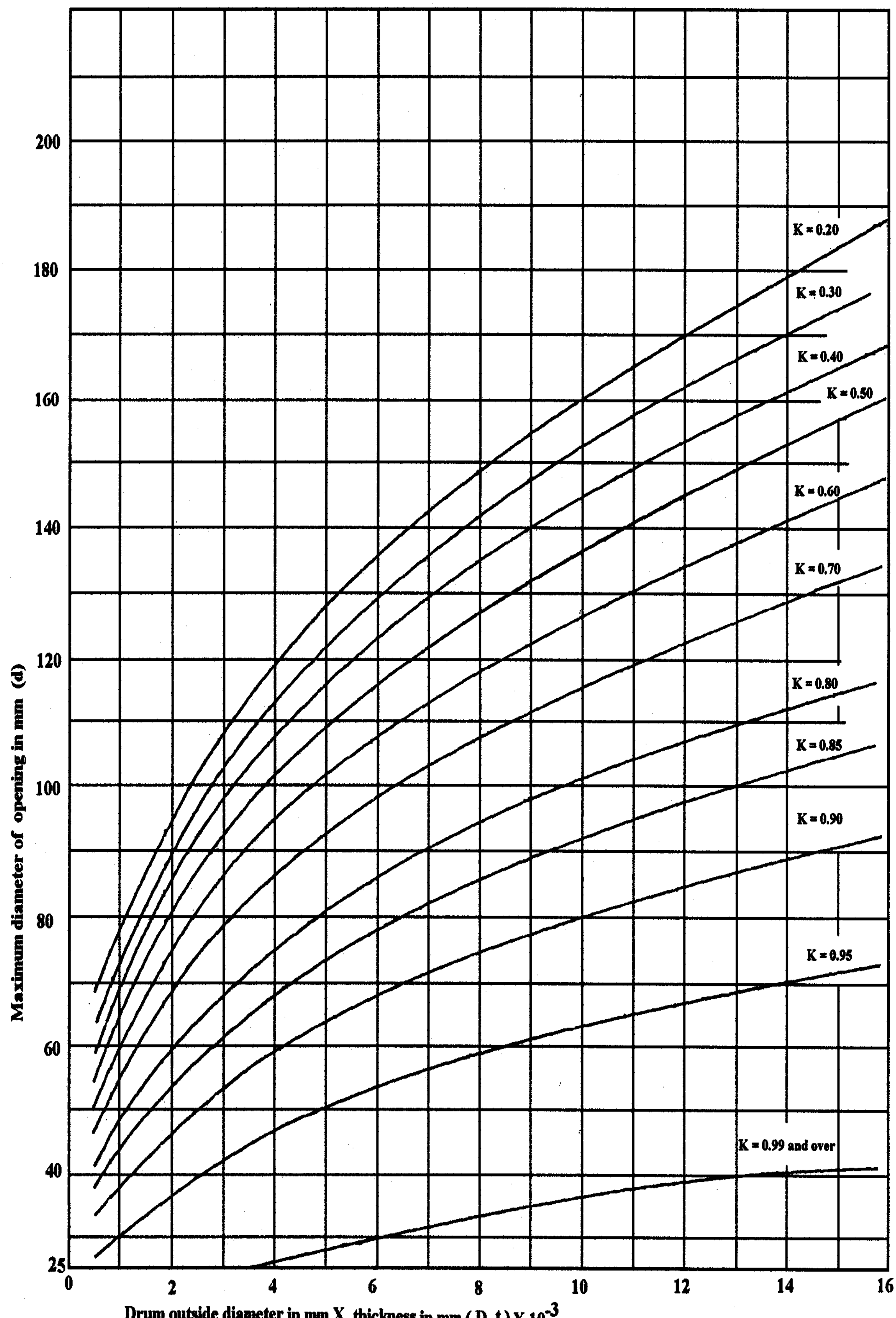


Fig. 2.1.4.1 : Maximum diameter of unreinforced openings

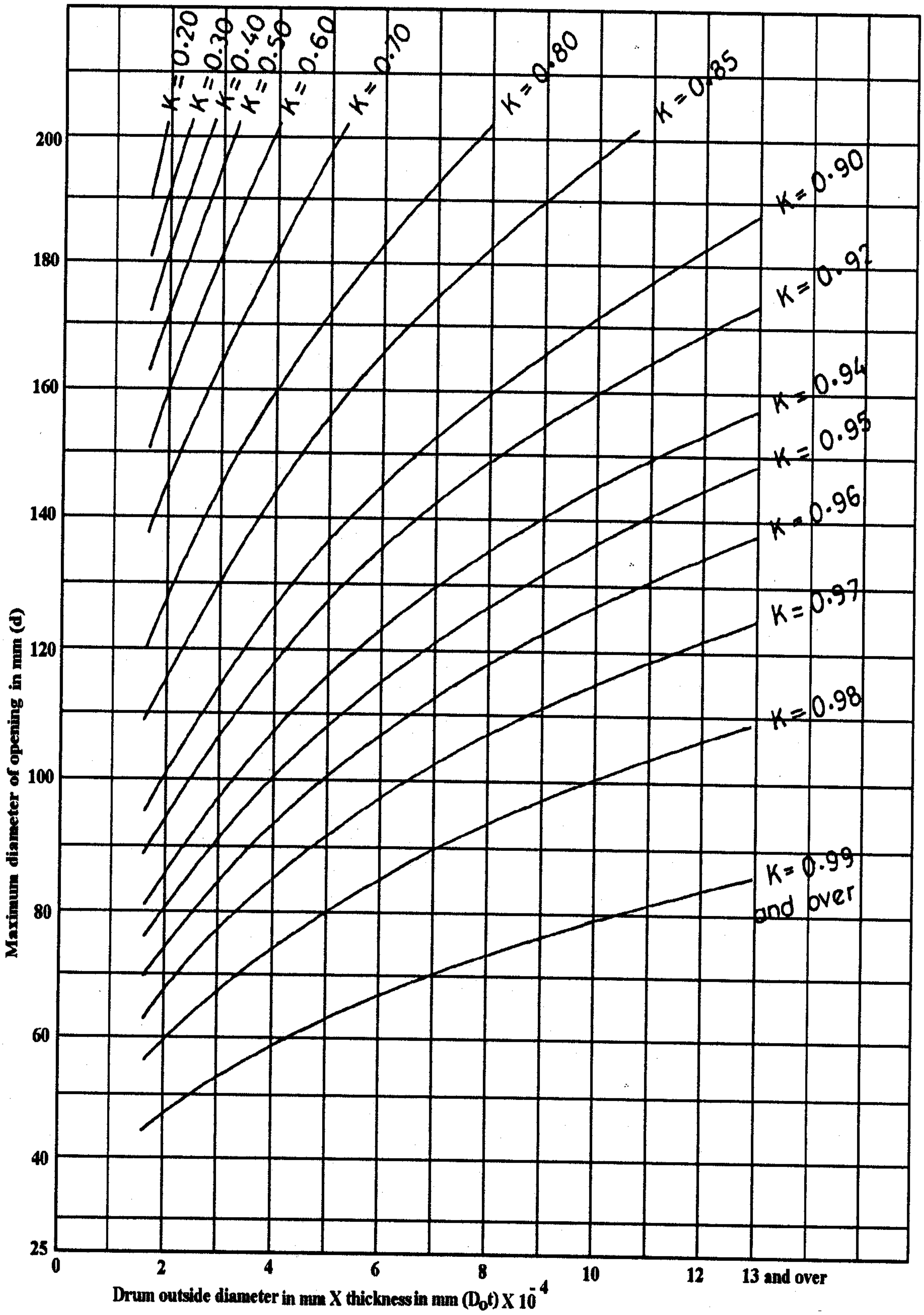


Fig. 2.1.4.2 : Maximum diameter of unreinforced openings

Where two openings are offset on a diagonal line, the diagonal efficiency from Fig.2.1.2.7 may be used to derive an equivalent longitudinal center distance for the purpose of this paragraph.

2.1.5 Reinforced openings

2.1.5.1 The following notations are used in Fig.2.1.5.1(a),(b) and (c):

A = calculated thickness of shell without joint or opening;

B = thickness calculated in accordance with 2.7.1;

C = 0.8 $\sqrt{d_i\ t_b}$

D = $\sqrt{D_i\ t_a}$ and is not to exceed 0.5 d_i;

t_a = actual thickness of shell plate [mm];

t_b = actual thickness of standpipe stem or branch [mm];

t_r = thickness of added reinforcement [mm] (t_r will be zero when there is no compensating plate on the side of the shell under consideration);

d_i = internal diameter of standpipe or branch [mm];

D_i = internal diameter of cylindrical shell [mm].

2.1.5.2 Openings larger than those permitted by 2.1.4 are to be reinforced by the method shown in Fig.2.1.5.1. Compensation will be considered adequate when:

$$Y + Z\frac{\sigma_s}{\sigma} \geq X$$

where,

X = the area to be compensated and is indicated by X in Fig.2.1.5.1;

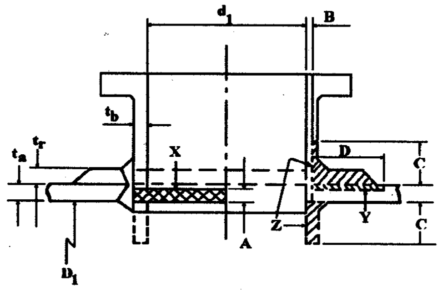
Y = the compensating area available in the shell material and is indicated by Y in Fig.2.1.5.1;

Z = the compensating area available in the standpipe material and is indicated by Z in Fig.2.1.5.1;

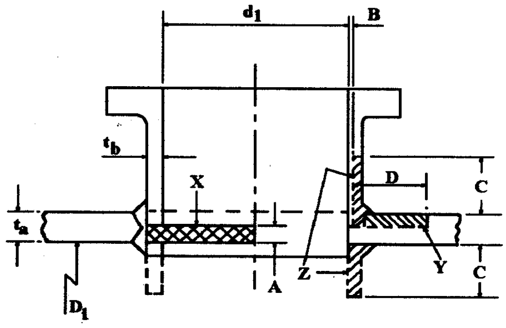
σ_s = the allowable stress of the standpipe material at design temperature;

σ = the allowable stress of shell material at design temperature;

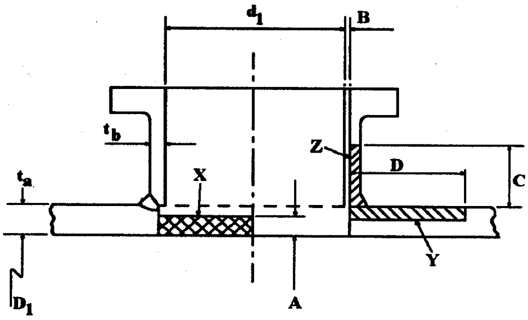
$\frac{\sigma_s}{\sigma}$ is to be taken as not greater than 1.



(a) Welded set-through nozzle with compensating plate



(b) Welded set-through nozzle



(c) Welded set-on nozzle

Fig. 2.1.5.1 : Compensation for welded

2.1.5.3 Area X is to be such that the reinforcement is provided on all planes through the center of the opening and normal to the shell surface, and is to be calculated as the product of the radius of the hole cut in the shell and the thickness, A, that would be required for an equivalent seamless unpierced shell.

2.1.5.4 Area Y is to be measured in the same plane as area X, and is to be calculated as the product of the difference between the actual shell thickness and the equivalent unpierced shell thickness, A, and the dimension from the edge of the opening in shell to limit D.

2.1.5.5 Area Z is to be measured in the same plane as area X, and is to be calculated as follows:

- For that part of standpipe which projects outside the shell, calculate the full cross-sectional area of the stem up to a distance C from the actual outer surface of the shell plate, and deduct from it the cross-sectional area which the stem would have if its thickness was as calculated in accordance with 2.7.1;
- **plus**, in the case of set- through nozzles (see Fig.2.1.5.1 (a) and (b), the full cross-sectional area of that part of the stem which projects inside the shell up to a distance of C, from the inside surface of the shell;
- **plus**, the cross-sectional area of all
- appropriate fillet welds;
- **plus**, if additional reinforcement is fitted as illustrated in Fig.2.1.5.1(b), the cross-sectional area of the reinforcement and the sectional area of its fillet welds.

2.1.5.6 The welds attaching standpipes and reinforcing plates to the shell are to be of sufficient size to transmit the full strength of the reinforcing areas and all other loadings to which they may be subjected.

2.2 Spherical shells subject to pressure on the concave side

2.2.1 Minimum thickness

2.2.1.1 The minimum thickness of a spherical shell is to be determined by the following formula:

$$t = \frac{p\,R_i}{20\,\sigma\,J - 0.5p} + 0.75 \text{ [mm]}$$

where,

p, R_i, σ, J and t are defined in Sec.1.

2.2.1.2 The formula in 2.2.1.1 is applicable only where the resulting thickness does not exceed half the internal radius.

2.2.2 Openings

2.2.2.1 Openings in spherical shells are to comply with the relevant requirements of 2.3.

2.3 Dished ends subject to pressure on concave side

2.3 1 Minimum thickness

2.3.1.1 The thickness, t, of semi-ellipsoidal, torispherical and hemispherical unstayed ends, dished from plate, having pressure on the concave side and satisfying the conditions listed below, is to be determined by the following formula:

$$t = \frac{p\,D_o K}{20\,\sigma\,J} + 0.75 \text{ [mm]}$$

where,

p, D_o, σ and J are defined in Sec.1;

K = a shape factor in accordance with 2.3.2 and Fig.2.3.1.1.

2.3.1.2 For semi-ellipsoidal ends:

the external height, H ≥ 0.18 Do, where D_o = the external diameter of the parallel portion of the end [mm].

2.3.1.3 For torispherical ends:

the internal radius, $R_i \le D_o$;

the internal knuckle radius, $r_i \ge 0.1\ D_o$;

the internal knuckle radius, $r_i \ge 3t$;

the external height, $H \ge 0.18\ D_o$, and is to be determined as follows:

$$H = R_o - \sqrt{\left(R_o - 0.5\,D_o\right)\left(R_o + 0.5\,D_o - 2\,r_o\right)}$$

2.3.1.4 In addition to the formula in 2.3.1.1, the thickness, t, is to be not less than that determined by 2.2.

2.3.1.5 In all cases, H is to be measured from the commencement of curvature, see Fig.2.3.1.2.(a),(b),(c) and (d).

2.3.1.6 For boilers (fired and exhaust gas heated), economisers, superheaters, reheaters, steam receivers, steam heated steam generators and similar vessels, the minimum thickness of the head, t, is to be not less than 9.5 [mm]. In special cases where it is proposed to use less than 9.5 [mm] thickness, the proposals will be subject to special consideration.

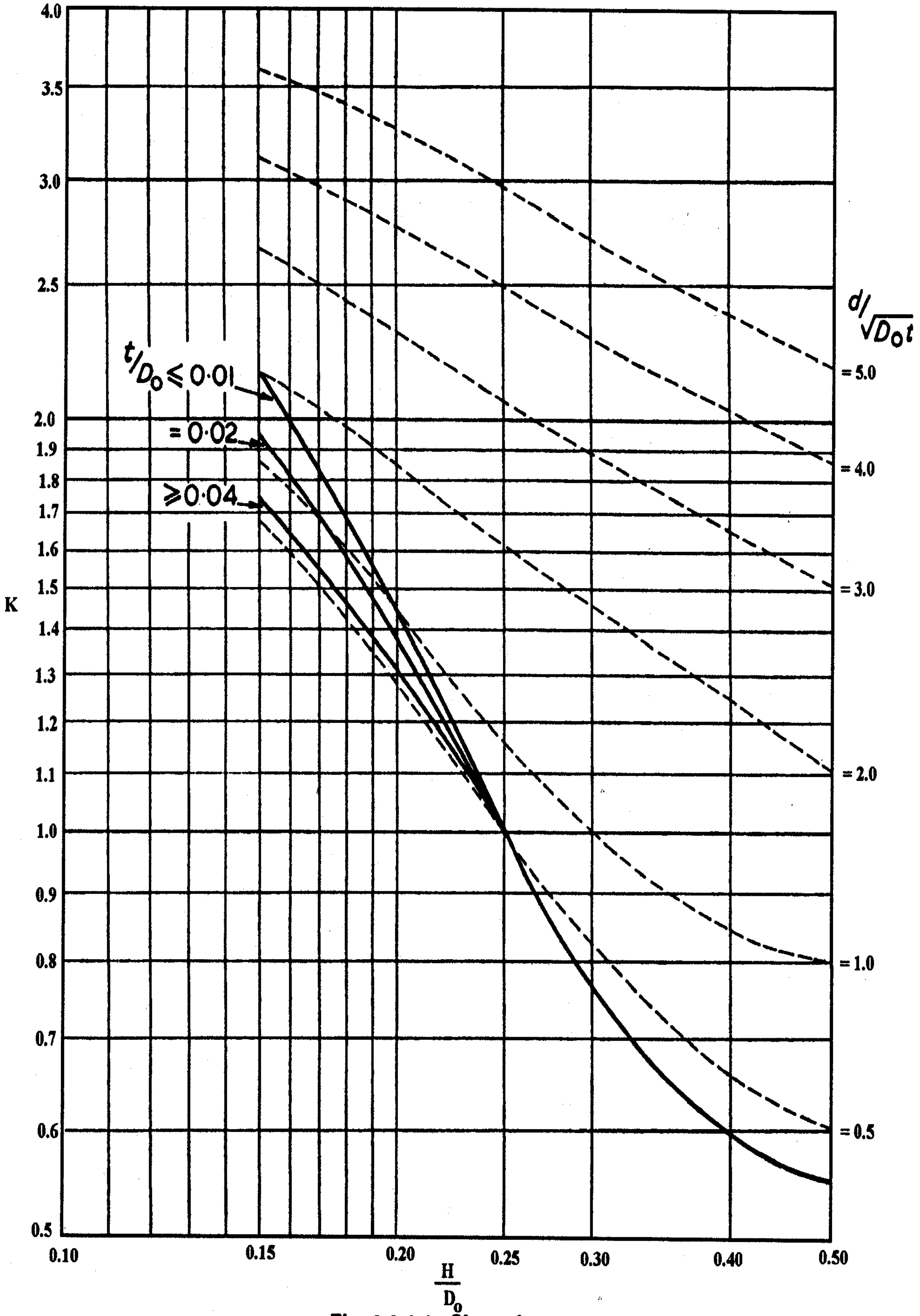


Fig. 2.3.1.1 : Shape factor

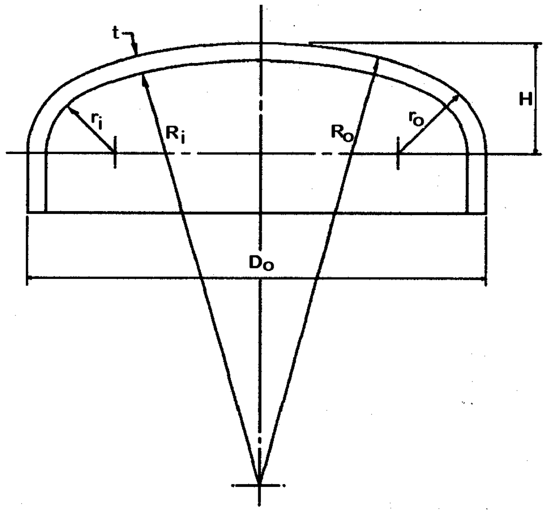


Fig. 2.3.1.2 (a) : Torispherical end

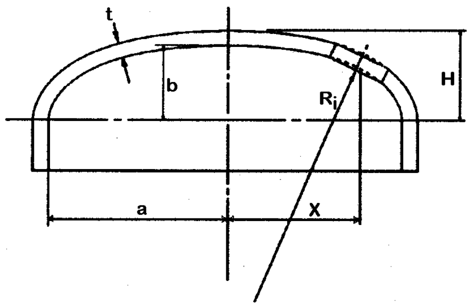


Fig. 2.3.1.2 (b) : Semi-ellipsoidal end

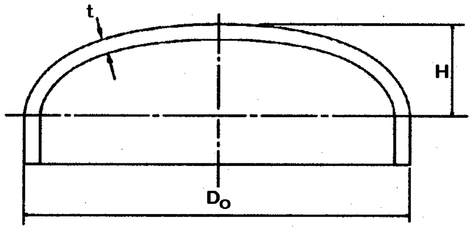


Fig. 2.3.1.2 (c) : Semi-ellipsoidal end (Radius of curvature at opening)

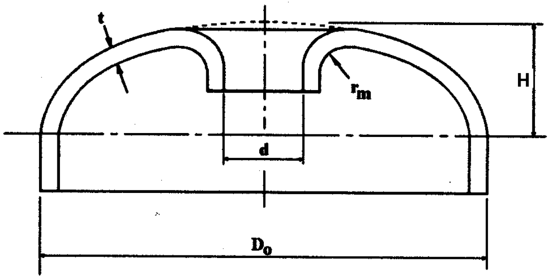


Fig. 2.3.1.2 (d) : End with manhole (Semi-ellipsoidal or torispherical)

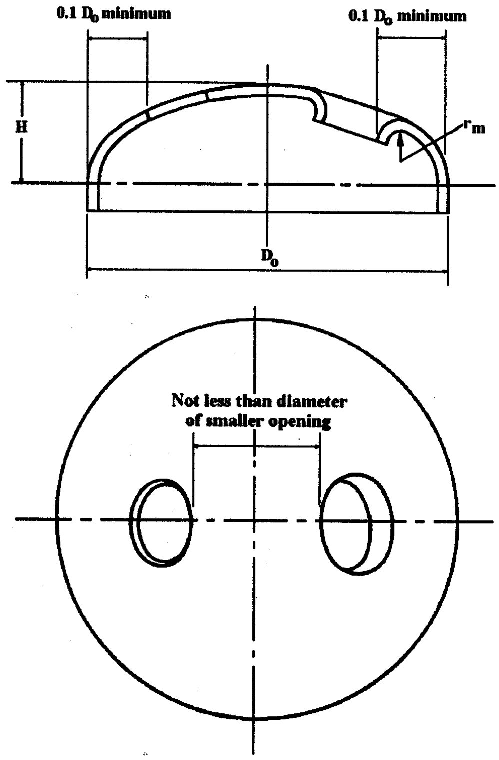


Fig. 2.3.1.3 : Openings in dished ends

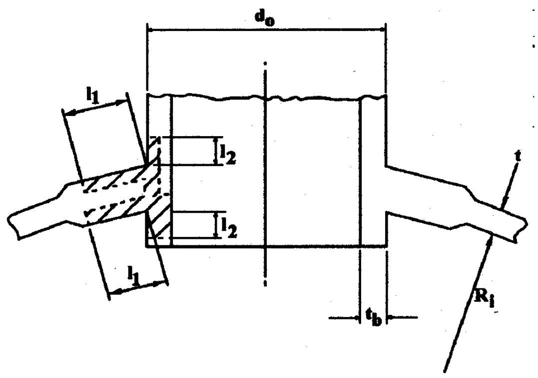


Fig. 2.3.1.4 : Limits of reinforcement

2.3.1.7 For ends which are butt welded to the drum shell, the thickness of the edge of the flange for connection to the shell is to be not less than the thickness of an unpierced seamless or welded shell, whichever is applicable, of the same diameter and material and determined by 2.1.

2.3.2 Shape factors for dished ends

2.3.2.1 The shape factor, K, to be used in 2.3.1.1 is to be obtained from the curves in

Fig.2.3.1.1, and depends upon the ratio of height to diameter H/D_o.

2.3.2.2 The lowest curve in the series provides the factor K for plain ends without openings or with small openings not requiring reinforcement. For lower values of H/D_o, the shape factor, K, depends on the ratio of thickness to diameter, t/D_o, as well as the ratio H/D_o and a trial calculation may be necessary to arrive at the correct value of K.

2.3.3 Dished ends with unreinforced openings

2.3.3.1 The openings in dished ends may be circular or approximately elliptical.

2.3.3.2 The upper curves in Fig.2.3.1.1 provide values of K to be used in 2.3.1.1 for ends with unreinforced openings. The selection of the correct curve depends on the value $\frac{d}{\sqrt{D_o t}}$ and a trial calculation is necessary to select the correct curve.

where,

d = the diameter of the largest opening in the end plate [mm] (in the case of an elliptical opening, the larger axis of the ellipse);

t = minimum thickness, after dishing [mm];

D_o = outside diameter of dished end [mm].

2.3.3.3 The following requirements must in any case be satisfied:

$$\frac{t}{D_o} \leq 0.1$$

$$\frac{d}{D_o} \leq 0.7$$

2.3.3.4 From Fig.2.3.1.1 for any selected ratio H/D_o, the curve for unpierced ends gives a value for $\frac{d}{\sqrt{D_o t}}$ as well as for K. Openings giving a value of $\frac{d}{\sqrt{D_o t}}$ not greater than the value so obtained may thus be pierced through an end designed as unpierced without any increase in thickness.

2.3.4 Flanged openings in dished ends

2.3.4.1 The requirements in 2.3.3 apply equally to flanged openings and to unflanged openings cut in the plate of an end. No reduction may be made in the end plate thickness on account of flanging.

2.3.4.2 Where openings are flanged, the radius, r_m, of the flanging is to be not less than 25 [mm], See Fig.2.3.1.2(d). The thickness of the flanged portion may be less than the calculated thickness.

2.3.4.3 Unreinforced and flanged openings in dished ends are to be so arranged that the distance from the edge of the hole to the outside edge of the plate and the distance between openings are not less than those shown in Fig.2.3.1.3.

2.3.5 Dished ends with reinforced openings

2.3.5.1 Where it is desired to use a large opening on a dished end of less thickness than would be required by 2.3.3, the end is to be reinforced. This reinforcement may consist of a ring or standpipe welded into the hole, or of reinforcing plates welded to the outside and/or inside of the end in the vicinity of the hole, or a combination of both methods, see Fig.2.3.1.4. Forged reinforcement may be used.

2.3.5.2 Reinforcing material within the following limits may be taken as effective reinforcement:

a) The effective width l_1, of reinforcement is not to exceed $\sqrt{2 R_i t}$ or 0.5 d_o whichever is the lesser;

b) The effective length l_2 of a reinforcing ring is not exceed $\sqrt{d_o t_b}$;

where,

R_i = The internal radius of the spherical part of a torispherical end [mm]; or

= the internal radius of the meridian of the ellipse at the center of the opening, of a semi-ellipsoidal end, [mm], and is given by the following formula:

$$\frac{[a^4 - x^2(a^2 - b^2)]^{1.5}}{a^4 b}$$

where,

a, b and x are shown in Fig.2.3.1.2(c);

t_b = actual thickness of ring or standpipe [mm];
d_o = external diameter of ring or standpipe [mm];
l_1 and l_2 are shown in Fig.2.3.1.4.

2.3.5.3 The shape factor, K, for a dished end having a reinforced opening can be read from Fig.2.3.1.1 using the value obtained from:

$$\frac{d_o - A/t}{\sqrt{D_o\, t}} \text{ instead of from } \frac{d}{\sqrt{(D_o\, t)}}$$

where,

A = the effective cross-sectional area of reinforcement and is to be twice the area shown shaded on Fig.2.3.1.4.

A trial calculation is necessary to select the correct curve.

2.3.5.4 The area shown in Fig.2.3.1.4 is to be obtained as follows:-

- calculate the cross-sectional area of reinforcement both inside and outside the end plate within the length l_1;

- **plus** the full cross-sectional area of that part of the ring or standpipe which projects inside the end plate up to the distance l_2;

- **plus** the full cross-sectional area of that part of the ring or standpipe which projects outside the internal surface of the end plate up to a distance l_2;

- and **deduct** the sectional area which the ring or standpipe would have if its thickness were as calculated in accordance with 2.7.1.

2.3.5.5 If the material of the ring or the reinforcing plates has an allowable stress value lower than that of the end plate, then the effective cross-sectional area, A, is to be multiplied by the ratio:-

$$\frac{\text{allowable stress of reinforcing plate at design temperature}}{\text{allowable stress of end plate at design temperature}}$$

2.4 Conical ends subject to internal pressure

2.4.1 Minimum thickness

2.4.1.1 The minimum thickness, t, of the cylinder, knuckle and conical section at the junction and within the distance L from the junction is to be determined by the following formula, but in no case is to be less than the thickness determined by 2.4.1.3:-

$$t = \frac{p\, D_o\, K}{20\, \sigma\, J} + 0.75 \text{ [mm]}$$

where,

t, p, σ and J are defined in Sec.1;

D_o = outside diameter, in [mm], of the conical section or end, see Fig.2.4.1.1(a),(b),(c) and (d);

K = a factor, taking in to account the stress in the knuckle, see Table 2.4.1.1.

2.4.1.2 If the distance of a circumferential seam from the knuckle or junction is not less than L, then J is to be taken as 1.0, otherwise J is to be taken as the weld joint factor appropriate to the circumferential seam;

where,

L = distance, in [mm], from knuckle or junction within which meridional stresses determine the required thickness, see Fig.2.4.1.1;

$$= 0.5\sqrt{\frac{D_o t}{\cos\psi}}$$

r_i = inside radius of transition knuckle, in [mm], which is to be taken as 0.01 Dc in case of conical sections without knuckle transition.

2.4.1.3 The minimum thickness, t, of those parts of conical sections not less than a distance L from the junction with a cylinder or other conical section is to be determined by the following formula:-

$$t = \frac{p\, D_c}{(20\, \sigma\, J - p)\cos\alpha} + 0.75 \text{ [mm]}$$

where,

D_c = inside diameter, in [mm], of conical section or end at the position under consideration, see Fig.2.4.1.1;

α1, α2, α3 = angle of slope of conical section (at the point under consideration) to the vessel axis, see Fig.2.4.1.1.

2.4.1.4 Conical ends may be constructed of several ring sections of decreasing thickness, as determined by the corresponding decreasing diameter.

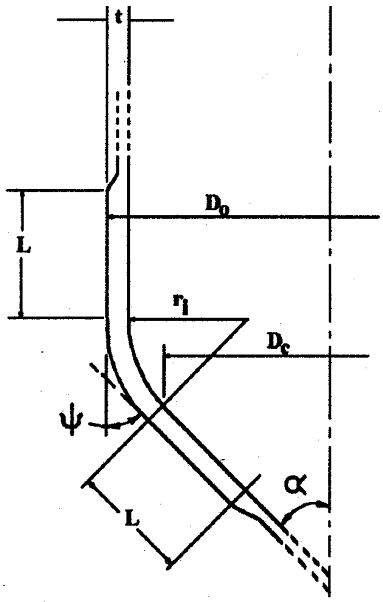


Fig. 2.4.1.1 (a) : Cone/cylinder with knuckle

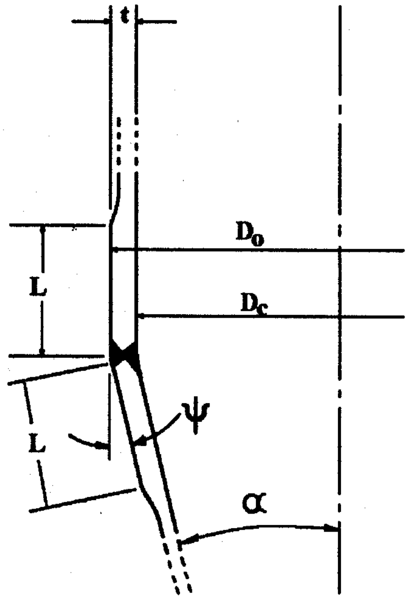


Fig. 2.4.1.1 (b) : Cone/cylinder without knuckle

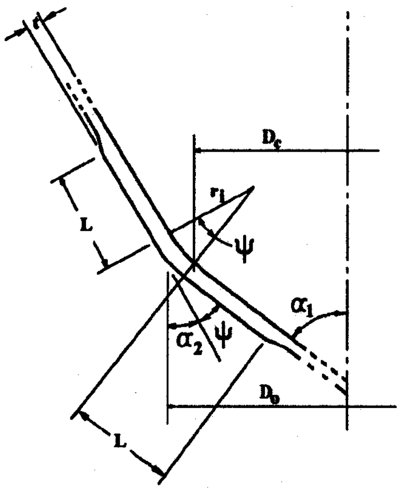


Fig. 2.4.1.1 (c) : Cone/cone with knuckle

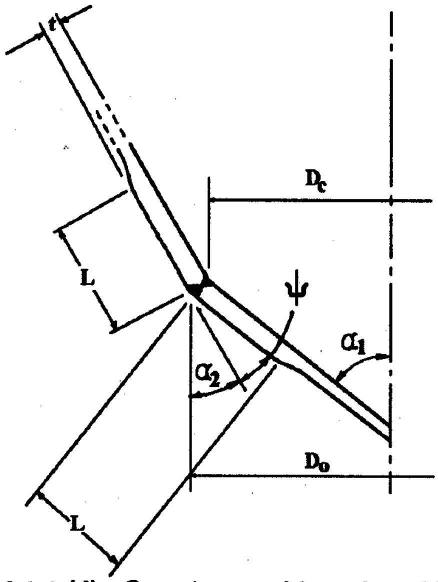


Fig. 2.4.1.1 (d) : Cone/cone without knuckle

Table 2.4.1.1 : Values of K as a function of ψ and r_i/D_o

	Values of K for r_i/D_o ratios											
ψ	**0.01**	**0.02**	**0.03**	**0.04**	**0.06**	**0.08**	**0.10**	**0.15**	**0.20**	**0.30**	**0.40**	**0.50**
10°	0.70	0.65	0.60	0.60	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
20°	1.00	0.90	0.85	0.80	0.70	0.65	0.60	0.55	0.55	0.55	0.55	0.55
30°	1.35	1.20	1.10	1.00	0.90	0.85	0.80	0.70	0.65	0.55	0.55	0.55
45°	2.05	1.85	1.65	1.50	1.30	1.20	1.10	0.95	0.90	0.70	0.55	0.55
60°	3.20	2.85	2.55	2.35	2.00	1.75	1.60	1.40	1.25	1.00	0.70	0.55
75°	6.80	5.85	5.35	4.75	3.85	3.50	3.15	2.70	2.40	1.55	1.00	0.55

2.4.1.5 The thickness of conical sections having an angle of inclination to the vessel axis of more than 75 degrees is to be determined as for a flat plate.

2.5 Unstayed flat end plates

2.5.1 Minimum thickness

2.5.1.1 The thickness of an unstayed flat end plate is to be determined in accordance with 2.7.3.3 or 2.8.1.7 or 2.8.1.8 as applicable.

2.6 Standpipe and branches

2.6.1 Minimum thickness

2.6.1.1 The minimum wall thickness of standpipes and branches is to be not less than that determined by 2.7.1. In determining the wall thickness of branches, internal pressure in addition to loads by connected piping and vibrations are to be taken into account. The thickness, however, is not to be less than:

$t = 0.04\ D_o + 2.5$ [mm]

where,

t and D_o are as defined in Sec.1.

2.6.1.2 In no case need the wall thickness exceed that of the shell.

2.6.1.3 Where standpipe or branch is connected by screwing, the thickness is to be measured at the root of the threads.

2.7 Particular design requirements for boilers, superheaters, economizers, steam receivers and similar vessels

2.7.1 Boiler tubes subject to internal pressure

2.7.1.1 The minimum wall thickness of straight tubes subject to internal pressure is to be determined by the following formula:

$$t = \frac{p\,D_o}{20\sigma + p} \text{ [mm]}$$

where,

t, p, D_o and σ are as defined in Sec.1. The thickness is in no case to be less than that shown in Table 2.7.1.

2.7.1.2 If the tube is ordered with a minus tolerance, the minimum thickness according to the formula in 2.7.1.1 is to be increased by the necessary amount. Where tubes are bent, the thickness of the thinnest part of the tube is not to be less than the calculated thickness, unless it can be demonstrated that the method of bending results in no decrease in strength at the bend as compared with the straight tube. In connection with any new method of bending, the manufacturer is to prove that this condition is satisfied.

2.7.1.3 For boiler, superheater and economizer tubes, the wall thickness required for the drum or header connection or tube stub is to be calculated as part of the tube.

2.7.1.4 The minimum thickness of downcomer tubes and pipes which form an integral part of the boiler and which are not exposed to combustion gases is to comply with the requirements for steam pipes.

Table 2.7.1 : Minimum thickness of tubes

Nominal outside diameter of tube [mm]	Minimum thickness [mm]	Minimum thickness [mm], See Note
≤ 38	1.75	2.95
> 38 ≤ 50	2.16	2.95
> 50 ≤ 70	2.40	2.95
> 70 ≤ 75	2.67	3.28
> 75 ≤ 95	3.05	3.28
> 95 ≤ 100	3.28	3.28
> 100 ≤ 125	3.50	3.50

Note : Applicable to tubes subject to internal pressure and fitted in cylindrical boilers and also for the tubes of low pressure water tube boilers having a design pressure of 1.72 [N/mm^2] and under with open feed system.

2.7.2 Boiler tubes subject to external pressure

2.7.2.1 The wall thickness of tubes with outside diameter 100 [mm] and less is not to be less than:

$$t = \frac{p\,D_o}{157\,\sigma}\ [\text{mm}]$$

where,

t, p, D_o and σ are as defined in Sec.1;

The nominal thickness of plain boiler tubes is, however, in no case to be less than given in Table 2.7.2.

Table 2.7.2 : Thickness of plain tubes under external pressure

Outside diameter of tube [mm]	Nominal thickness of tube [mm]				
	2.9	3.2	3.6	4.0	4.5
Design pressure [N/mm^2]					
51	1.1	1.5	2.1		
57	1.0	1.35	1.8	2.2	
63.5	0.9	1.25	1.6	2.1	
70	0.8	1.1	1.5	1.95	
76.1		1.0	1.35	1.75	2.1
82.5		0.9	1.25	1.6	1.95
88.9		0.85	1.15	1.5	1.8

2.7.2.2 Regarding minus tolerance and reduction in thickness due to bending, see 2.7.1.2.

2.7.2.3 Plain tubes may be seal welded at both ends, seal welded at the inlet end and expanded at the outlet end or expanded at both the ends. Where the tubes are seal welded, the tubes are to be expanded into the tube plates in addition to welding.

2.7.2.4 Where plain tubes are expanded only, the process is to be carried out with roller expanders, and the expanded portion of the tube is to be parallel through the full thickness of the tube plate. In addition to expanding, tubes may be bellmouthed or beaded at the inlet end.

2.7.2.5 Where the total number of tubes are arranged in one nest and no stay tubes are fitted, the ends of all tubes are to be welded or expanded and beaded at the inlet end, and welded or expanded at the outlet end.

2.7.2.6 The spacing of the tube holes is to be such that the minimum width, in [mm], of any ligament between the tube holes is not less than:

$$0.125\ d + 12.5\ [\text{mm}]$$

where,

d = diameter of tube hole [mm].

2.7.3 Headers

2.7.3.1 Circular headers

2.7.3.1.1 The minimum thickness of circular section headers is to be calculated in accordance with 2.1.

2.7.3.2 Rectangular section headers

2.7.3.2.1 The thickness of flat surfaces of rectangular solid forged headers is to be not less than (t + 0.75) [mm], where t = the greatest basic thickness, in [mm], derived by the use of Fig.2.7.3.1.

2.7.3.2.2 Fig.2.7.3.1 shows values of t/B corresponding to the values of term K, for parameters of A/B;

where,

A = the distance, in [mm], between centerline of the openings and the limit of the effective width, B, of the header. Where there is more than one row of holes, A is the distance to the row showing the lowest efficiency;

B = the effective width, in [mm], of the pierced surface under consideration measured between the supporting sides of the headers, minus one corner radius. The effective width is not to be taken as less than 0.9 of the full distance between the sides;

$$K = \frac{10\sigma J}{p}$$

where,

σ and p are as defined in Sec.1;

J = the efficiency of the ligaments as calculated in 2.1.2. Where there are several rows of tube holes, the lowest calculated efficiency is to be used.

2.7.3.2.3 Investigations of two stresses are necessary:

- the stress at the corner of the header, where A/B = 0 and J = 1, see Fig.2.7.3.1;

- and the stress in the ligaments between tube holes or other openings piercing the flat face of the header.

2.7.3.2.4 The corner radius is not to be less than 6.5 [mm].

2.7.3.2.5 Where the header surfaces are machined locally at hand holes, the total thickness may be reduced by a maximum of 4 [mm].

2.7.3.2.6 Except for small areas not exceeding 325 [mm^2], where a reduction of designed thickness up to 50 per cent may be permitted, the thickness derived from the use of Fig.2.7.3.1 is to be the minimum. Such minimum is in no case to be less than 7.5 [mm] or where tube holes are drilled, to be less than:-

$$t = 0.5\sqrt{d} + 6.35 \text{ [mm]}$$

where,

d = the diameter of the tube holes [mm].

2.7.3.3 Header ends

2.7.3.3.1 The shape and thickness of ends forged integrally with the bodies of headers are to be the subject of special consideration. Where sufficient experience of previous satisfactory service of headers with integrally forged ends cannot be shown, the suitability of a proposed form of end is to be proved in accordance with 1.10.

2.7.3.3.2 Ends attached by welding are to be designed as follows:-

a) Dished Ends: these are to be in accordance with 2.3

b) Flat Ends: the minimum thickness of flat end plates is to be determined by the following formula:-

$$t = d_i\sqrt{\frac{pC}{10\sigma}}$$

where,

p and σ are as defined in Sec.1;

t = minimum thickness of end plate [mm];

d_i = internal diameter of circular header or least width between walls of rectangular header [mm];

C = a constant depending on method of end attachment, see Fig.2.7.3.2

For end plates welded as shown in Fig.2.7.3.2 (a):

C = 0.19 for circular headers;

= 0.32 for rectangular headers;

For end plates welded as shown in Fig.2.7.3.2 (b) and (c):

C = 0.28 for circular headers;

= 0.40 for rectangular headers.

2.7.3.3.3 Where flat end plates are bolted to flanges attached to the ends of headers, the flanges and end plates are to be in accordance with recognized pipe flange standards.

2.7.4 Flat surfaces and flat tube plates

2.7.4.1 Stayed flat surfaces

2.7.4.1.1 Where flat end plates are flanged for connection to the shell, the inside radius of flanging is to be not less than 1.75 times the thickness of the plate, with a minimum of 38 [mm].

2.7.4.1.2 Where combustion chamber of firebox plates are flanged for connection to the wrapper plate, the inside radius of flanging is to be equal to the thickness of the plate, with a minimum of 25 [mm].

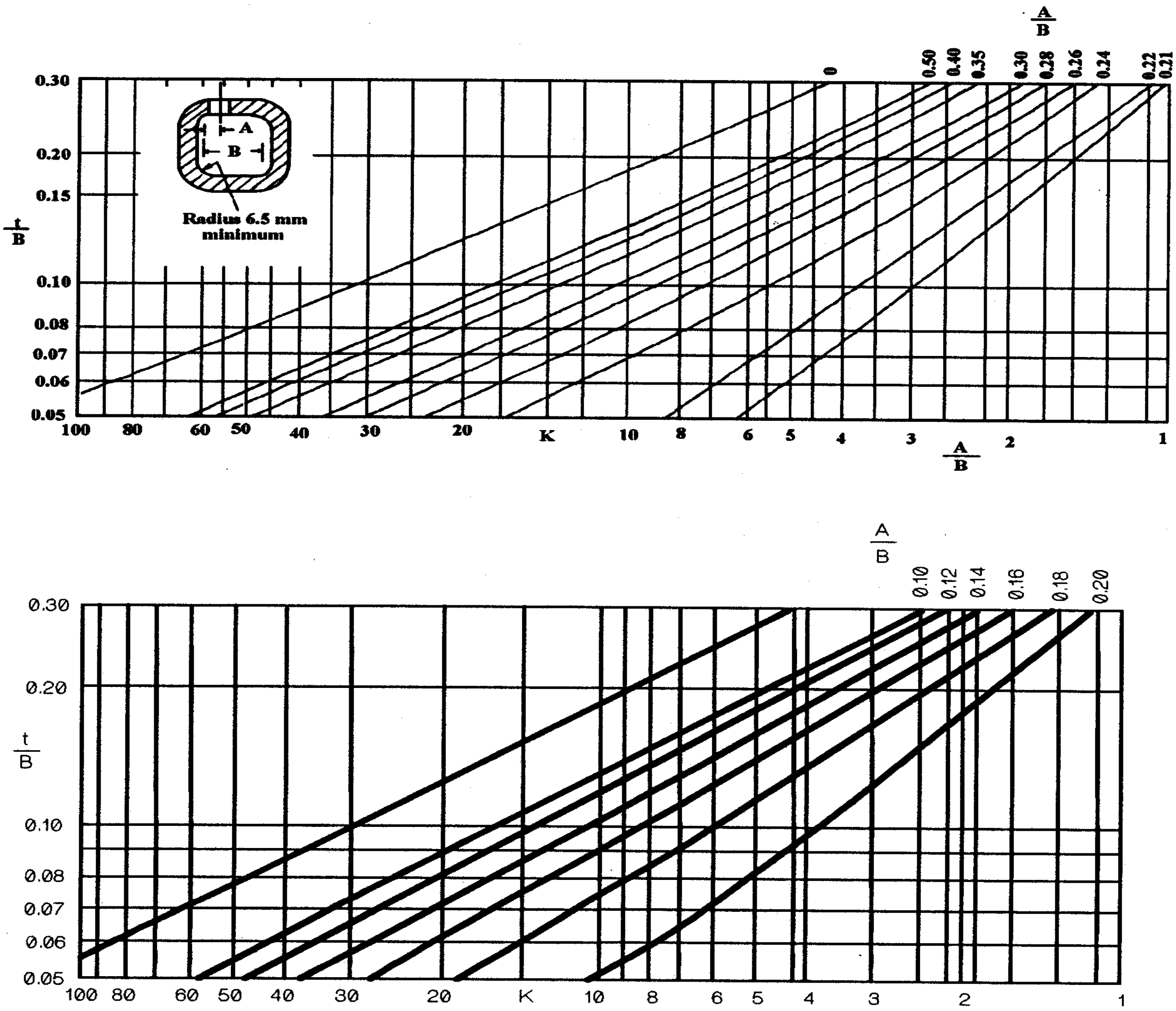


Fig. 2.7.3.1 : Rectangular section headers

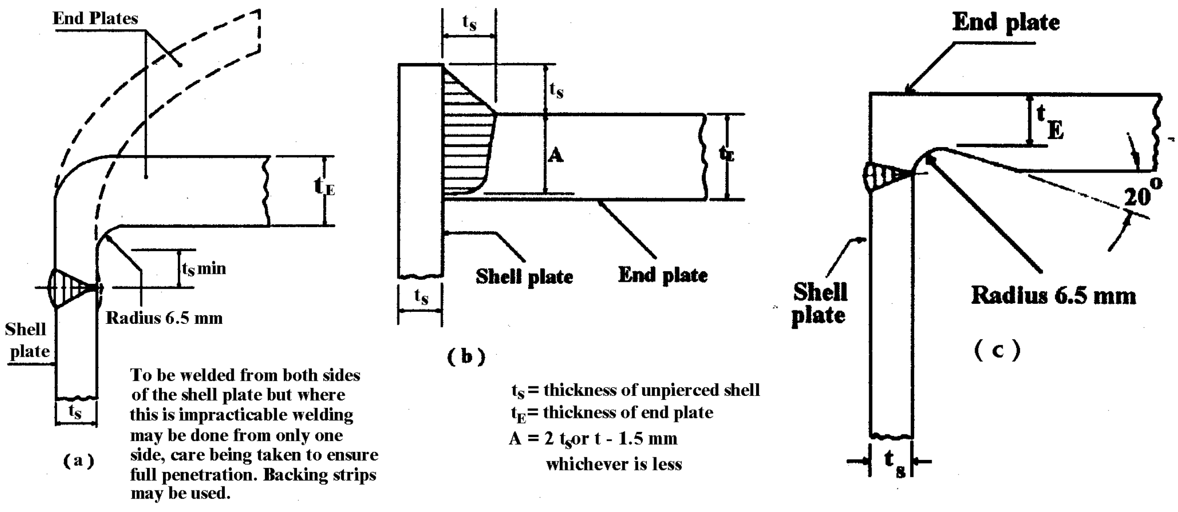


Fig. 2.7.3.2 : Typical methods of attachment of headers and closures

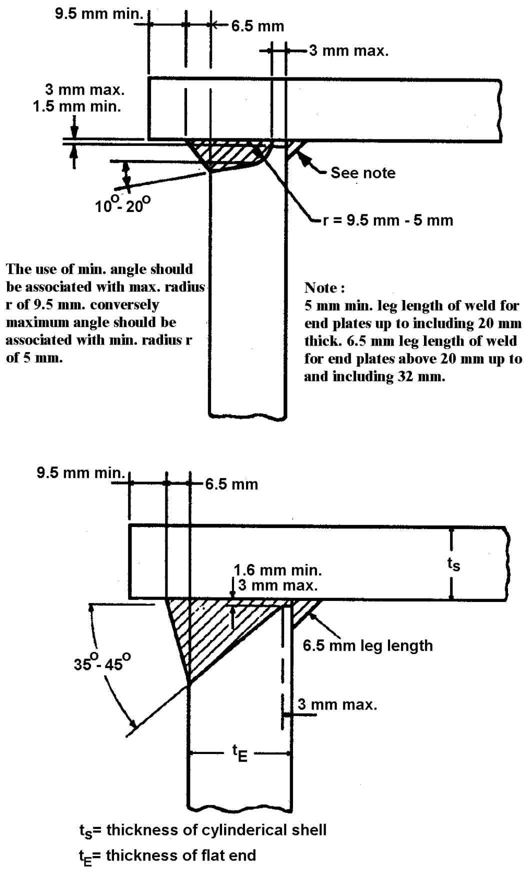


Fig.2.7.4.1 : Attachment of unflanged end plate to shell

2.7.4.1.3 Where unflanged flat plates are connected to the shell by welding, the methods of attachment are to be as shown in Fig.2.7.4.1. Similar forms of attachment may be used where unflanged combustion chamber or firebox plates are connected to the wrapper plate by welding.

2.7.4.1.4 Where the flange curvature is a point of support, this is to be taken at the commencement of curvature, or at a line distant 3.5 times the thickness of the plate from the outside of the plate, whichever is nearer to the flange.

2.7.4.1.5 Where a flat plate is welded directly to a shell or wrapper plate, the point of support is to be taken at the inside of the shell or wrapper plate.

2.7.4.1.6 The thickness, t, of those portions of flat plates supported by stays is to be determined by the following formula:

$$t = C\,d\sqrt{\frac{p}{10\,\sigma_1}} + 0.75 \ \ [\mathrm{mm}]$$

where,

t and p are as defined in Sec.1;

$\sigma_1 = 0.85\ \sigma$, where σ is as defined in Sec.1;

$d = \sqrt{A^2 + B^2}$ where the stays are regularly pitched

A = horizontal pitch of the stays

B = vertical pitch of the stays

where the tubes are irregularly pitched

d = diameter of the largest circle which can be drawn through three points of support without enclosing another point of support. Only two points of support may lie on one side of any diameter of the circle.

C = a constant, dependent on the method of support as detailed in 2.7.4.1.7. Where various forms of support are used, C is to be the mean of the values for the respective methods adopted.

2.7.4.1.7 All constants given in this paragraph relate to plates which are stress relieved and not exposed to flame. Where the plates are exposed to flame the thickness of the plate is to be increased by 10 per cent. The values of C in the formula in 2.7.4.1.6 is to be as follows:-

a) Where plain bar stays are strength welded in to the plates as shown in Fig.2.7.4.2.

   C = 0.39

b) Where plain bar stays pass through holes in the plates and are fitted on the outside with washers as shown in Fig.2.7.4.3.

   C = 0.35 where the diameter of the washer is 3.5 times the diameter of the stay.

   C = 0.33 where the diameter of the washer is 0.67 times the pitch of the stays.

c) Where the flat plate is flanged for attachment to the shell, flue, furnace or wrapper or, alternatively, is welded directly to the shell, flue, furnace or wrapper.

   C = 0.33

d) where the support is a gusset or link stay

   C = 0.39

2.7.4.1.8 Alternative methods of support will be specially considered.

2.7.4.1.9 Where a flat plate has a manhole or sighthole and the opening is strengthened by flanging, the total depth, H, of the flange, measured from the outer surface of the plate, is to be not less than:

$$H = \sqrt{t\,W}$$

where,

H = depth of flange [mm];

t = thickness of plate [mm];

W = minor axis of manhole or sight hole [mm].

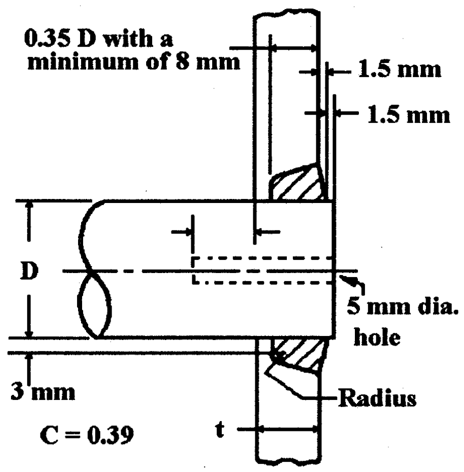


Fig. 2.7.4.2 : Attachment of firebox, combustion chamber and bar stays

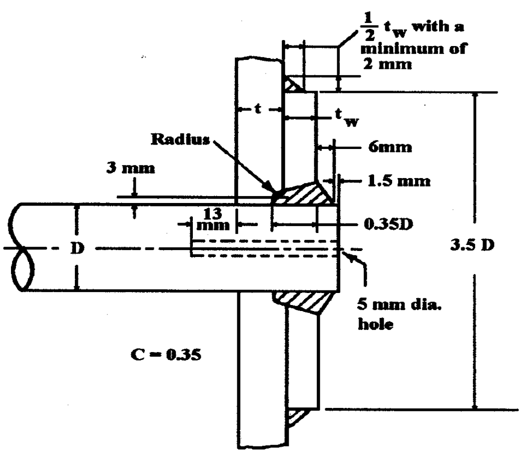


Fig. 2.7.4.3 : Attachment of bar stays

2.7.4.1.10 Where the flat top plates of combustion chambers are supported by welded-on girders, the equation in 2.7.4.1.6 is to apply as follows:

a) In the case of welded-on girders provided with waterways;

C = 0.42;

$$d = \sqrt{X^2 + Y^2}$$

where,

X = width of waterway in the girder plus the thickness of the girder [mm];

Y = pitch of girder [mm];

b) In the case of the continuously welded-on girders;

C = 0.51;

d = D;

where,

D = distance between inside faces of girders [mm].

2.7.4.2 Flat tube plates within tube nests

2.7.4.2.1 Stay tubes are to be fitted:

a) Where the total number of tubes are arranged in one nest, the area of which exceeds 0.65 [m^2] in the case of direct fired boilers, and 2.0 [m^2] in the case of waste heat boilers;

b) In all cases where the total number is arranged in more than one nest.

2.7.4.2.2 Where stay tubes are not fitted, the ends of all tubes are to be welded or expanded and beaded at the inlet end, and welded or expanded at the outlet end. For details of seal welding of plain tubes, see Fig.2.7.4.4.

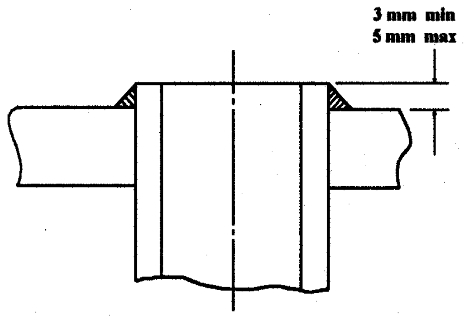


Fig. 2.7.4.4 : Detail of seal weld for plain tube

2.7.4.2.3 Where stay tubes are required to be fitted, the thickness of those parts of the tube plates within the tube nests is to be determined by the following formula:

$$t = C\,M\sqrt{\frac{p}{10\sigma_1}} + 0.75 \ \text{[mm]}$$

where,

t = thickness of tube plate [mm];

p = design pressure [N/mm^2];

σ_1 = 0.85 σ, where σ is as defined in Sec.1;

M = mean pitch, in [mm], of the stay tubes supporting any positions of the plate (being the sum of the four sides of any quadrilateral divided by 4);

C = 0.42 for plates not exposed to flame with stay tube secured as shown in Fig.2.7.4.5;

C = 0.46 for plates exposed to flame.

2.7.4.2.4 Where the area of the tube nest does not exceed 0.65 [m^2] in the case of direct fired boilers, or 2.0 [m^2] in the case of waste heat boilers, and stay tubes are not fitted, the thickness of the plate is to be determined by the formula in 2.7.4.2.3;

where,

M = Four times the mean pitch [mm], of the plain tubes in the nest;

C = 0.45 for plates not exposed to flame;

= 0.49 for plates exposed to flame.

2.7.4.2.5 The thickness, t, of any tube plate in the tube area is to be not less than:

a) 12.5 [mm], where the diameter of the tube hole does not exceed 50 [mm]; and

b) 14 [mm], where the diameter of the tube hole is greater than 50 [mm].

2.7.4.3 Flat tube plates between wide water spaces and around tube nests

2.7.4.3.1 The thickness of the tube plate in the wide water space between tube nests is to be determined by the following formula:

$$t = C\,d\sqrt{\frac{p}{10\sigma_1}} + 0.75 \ \text{[mm]}$$

where,

t = thickness of the tube plate [mm];

p = design pressure [N/mm^2];

σ_1 = 0.85 σ, where σ is as defined in Sec.1;

$$d = \sqrt{A^2 + B^2}$$

A = width [mm], of the wide water space between the tube nests (measured from the centerline of the stay tubes);

B = pitch [mm], of the stay tubes in boundary rows of wide water space;

C = 0.42, if the plates are not exposed to flame;

= 0.46, if the plates are exposed to flame.

2.7.4.3.2 The values of C and the method of securing the stay tubes are as indicated in 2.7.4.2.3.

2.7.4.3.3 Where stay tubes are irregularly pitched, d is to be taken as the diameter of the largest circle which can be drawn through any three points of support without enclosing another point of support. Where various forms of supports are used, the value of C is to be the mean of the values for the respective methods adopted.

2.7.4.3.4 For the portions of the end plates between the top rows of tubes and steam space stays, the formula in 2.7.4.3.1 is to apply, B being taken as the distance between the centerline of the top row of tubes and the center of the bar stays or other point of support, and A being taken as $\frac{A_1 + A_2}{2}$ where A_1 is the horizontal distance between the centers of bar stays or other methods of support, and A_2 is the horizontal distance between the center of one stay tube and the center of next stay tube in the top boundary row. Where no stay tubes are fitted, A_2 is to be taken as equal to four times the horizontal pitch of the plain tubes.

2.7.4.3.5 Where no stay tubes are fitted, the support afforded by the plain tubes are not to be taken to extend beyond the line enclosing the outer surfaces of the tubes except that, between the outside of the wing row of tubes and the attachment of the end plate to shell, there may be an unsupported width equal to the flat plate margin, as given by the formula in 2.7.4.6.1.

2.7.4.4 Combustion chamber tube plates under compression

2.7.4.4.1 The thickness of combustion chamber tube plates under compression due to the pressure on the top plate, based on a compressive stress not exceeding 960 bar is to be determined by the following formula:

$$t = \frac{pWs}{1930(s-d)} \text{ [mm]}$$

where,

t and p are as defined in Sec.1;

W = internal width of combustion chamber [mm], measured from tube plate to back chamber plate;

s = pitch of tubes [mm], measured horizontally where tubes are chain pitched, or diagonally where the tubes are staggered pitched and the diagonal pitch is less than the horizontal pitch;

d = internal diameter of plain tubes.

2.7.4.5 Girders for combustion chamber top plates

2.7.4.5.1 The formula in 2.7.4.5.2 is applicable to plate girders welded continuously to the top combustion chamber plates by means of a full penetration weld.

2.7.4.5.2 The proportion of steel plate girders supporting the tops of combustion chambers is to be determined by the following formula:

$$t = \frac{0.32\, p\, l^2\, s}{d^2\, R_{20}} \text{ [mm]}$$

where,

t and p are as defined in Sec.1;

d = depth of girder [mm];

l = length of girder [mm], measured internally from tube plate to back chamber plate;

s = distance apart of the girders [mm];

R_{20} = specified minimum tensile strength of the girder plate [N/mm^2].

2.7.4.6 Flat plate margins

2.7.4.6.1 The width of margin, b, of a flat plate which may be regarded as being supported by the shell, furnaces or flues to which the flat plate is attached is not to exceed that determined by the following formula:

$$b = \frac{C(t-0.75)}{\sqrt{p}} \text{ [mm]}$$

where,

t and p are as defined in Sec.1;

b = width of margin [mm];

C = 31.0 for plates not exposed to flame;

= 28.8 for plates exposed to flame.

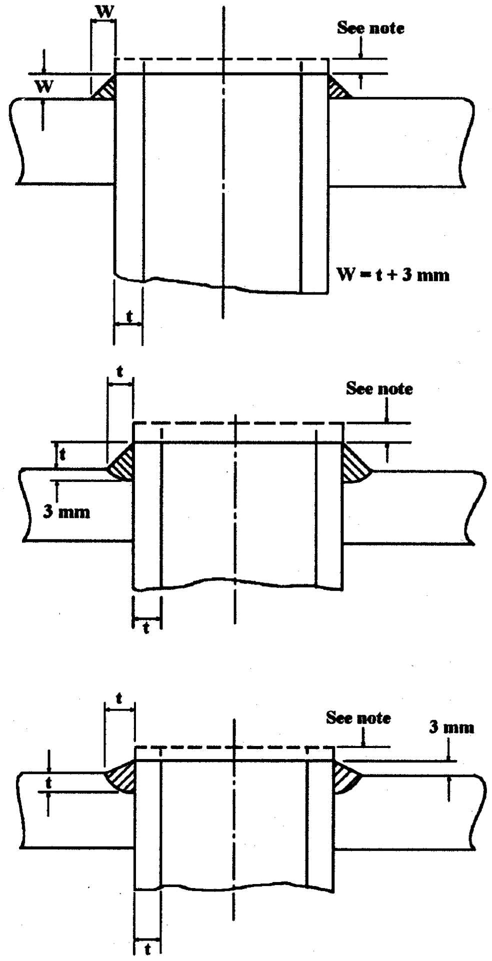
2.7.4.6.2 Where an unflanged flat plate is welded directly to shell, furnaces or flues and it is not practicable to effect the full penetration weld from both sides of the flat plate, the constant C used in formula in 2.7.4.6.1 is to be:

C = 23.6 for plates not exposed to flame;

= 22.3 for plates exposed to flame.

2.7.4.6.3 In the case of plates which are flanged, the margin is to be measured from the commencement of curvature of flanging, or from a line 3.5 times the thickness of the plate, measured from the outside of the plate, whichever is nearer to the flange.

2.7.4.6.4 Where the flat plate is not flanged for attachment to the shell, furnaces or flues, the margin is to be measured from the inside of the shell or the outside of the furnaces or flues, whichever is applicable.



Note : The ends of the tubes are to be dressed flush with the welds and then exposed to flame or comparitively high temperature. When not exposed, the ends of the tubes may extend a maximum of 9.5 [mm] beyond the weld.

Fig. 2.7.4.5 : Attachment of stay tubes

2.7.4.6.5 In no case is the diameter, D, in [mm], of the circle forming the boundary of the margin supported by the uptake of a vertical boiler to be greater than determined by the following formula:

$$D = \sqrt{\frac{345}{p} + d^2} \text{ [mm]}$$

where,

A = cross-sectional area of the uptake tube [mm^2];

p = design pressure in bar;

d = external diameter of uptake [mm].

2.7.5 Flat plates and ends of vertical boilers

2.7.5.1 Tube plates of vertical boilers

2.7.5.1.1 Where vertical boilers have a nest or nests of horizontal tubes, so that there is direct tension on the tube plates due to the vertical load on the boiler ends or to their acting as horizontal ties across the shell, the thickness of the tube plates in way of the outer rows of tubes are to be determined by the following formula:

$$t = \frac{pD}{5JR_{20}} + 0.75 \text{ [mm]}$$

where,

t and p are as defined in Sec.1;

D = twice the radial distance of the center of the outer row of tube holes from the axis of the shell [mm];

R_{20} = specified minimum tensile strength of tube plate [N/mm^2];

J = efficiency of ligaments between tube holes in the outer vertical rows (expressed as a fraction);

$$= \frac{s - d}{s}$$

where,

s = vertical pitch of tubes [mm];

d = diameter of tube holes [mm].

2.7.5.1.2 Each alternate tube in the outer vertical rows of tubes is to be a stay tube. Further, the arrangement of stay tubes in the nests is to be such that the thickness of the tube plates meets the requirements of 2.7.4.2. and 2.7.4.3.

2.7.5.1.3 Where the vertical height of the tube plates between the top and bottom shelves exceeds 0.65 times the internal diameter of the boiler, the staying of the tube plates, and the scantlings of the tube plates and shell plates to which the sides of the tube plates are connected will require to be specially considered. It is recommended, however, that for this type of boiler the vertical height of the tube plates between the top and bottom shelves should not exceed 1.25 times the internal diameter of the boiler.

2.7.5.2 Horizontal shelves of tube plates forming part of the shell

2.7.5.2.1 For vertical boilers of the type referred to in2.7.5.1, in order to withstand the vertical load due to pressure on the boiler ends, the horizontal shelves of the tube plates are to be supported by gussets in accordance with the following formula:

$$C = \frac{A\, D_i\, p}{t}$$

where,

A = maximum horizontal dimension of the shelf from the inside of the shell plate to the outside of the tube plate [mm];

D_i = inside diameter of the boiler [mm];

p = design pressure, in bar;

t = thickness of the tube plate [mm].

2.7.5.2.2 For the combustion chamber tube plate the minimum number of gussets are to be:

- 1 gusset where C exceeds 255 000
- 2 gussets where C exceeds 350 000
- 3 gussets where C exceeds 420 000

2.7.5.2.3 For the smoke box tube plate the minimum number of gussets are to be:

- 1 gusset where C exceeds 255 000
- 2 gussets where C exceeds 420 000

2.7.5.2.4 The shell plates to which the sides of the tube plates are connected are to be not less than 1.5 [mm] thicker than is required by the formula applicable to shell plates with continuous circularity; and where gussets or other stays are not fitted to the shelves, the strength of the parts of the circumferential seams at the top and bottom of these plates from the outside of one tube plate to the outside of the other, is to be sufficient to withstand the whole load on the boiler end with a factor of safety of not less than 4.5 related to R_{20} (where R_{20} is the specified minimum tensile strength of the shell plates [N/mm^2].

2.7.5.3 Dished and flanged ends for vertical boilers

2.7.5.3.1 The minimum thickness, t, of dished and flanged ends for vertical boilers which are subject to pressure on the concave side and are supported by central uptakes is to be determined by the following formula:

$$t = \frac{P\, R_i}{10\sigma_2} + 0.75 \text{ [mm]}$$

where,

t, p and R_i are as defined in Sec.1;

$\sigma_2 = 1.3\ \sigma$, where σ is defined in 1.6.

2.7.5.3.2 The inside radius of curvature, R_i, of the end plate is to be not greater than the external diameter of the cylinder to which it is attached.

2.7.5.3.3 The inside knuckle radius, r_i, of the arc joining the cylindrical flange to the spherical surface of the end is to be not less than four times the thickness of the end plate, and in no case less than 65 [mm].

2.7.5.3.4 The inside radius of curvature of flange to uptake is to be not less than twice the thickness of the end plate, and in no case less than 25 [mm].

2.7.5.3.5 If the dished end has a manhole, the opening is to be strengthened by flanging. The total depth, H, of the flange, measured from the outer surface of plate on the minor axis, is to be not less than:

$$H = \sqrt{t\,W}$$

where,

H = depth of flange [mm];

t = thickness of the plate [mm];

W = minor axis of manhole [mm].

2.7.5.4 Flat crowns of vertical boilers

2.7.5.4.1 The minimum thickness of flat crown plates of vertical boilers is to be determined as in 2.7.4; d and c are defined as follows:

a) Where the crown is supported by an uptake only;

d = diameter [mm], of the largest circle which can be drawn between the connections to the shell or fire box and uptake (see 2.7.4.1.1 to 2.7.4.1.5);

c = 0.47, if the plates are not exposed to flame;

= 0.51, if the plates are exposed to flame;

b) Where bar stays are fitted in accordance with 2.7.4.1.6 and 2.7.4.1.7;

d = diameter, in [mm], of the largest circle which can be drawn through three points of support without enclosing another point of support;

c = the mean of the values for the respective points of support through which the circle passes.

2.7.5.5 Dished and flanges ends for supported vertical boiler furnaces

2.7.5.5.1 The minimum thickness, t, of dished and flanged ends for vertical boiler furnaces that are subject to pressure on the convex side and are supported by central uptake, is to be determined by the following formula:

$$t = \frac{p\,R_o}{10\sigma} + 0.75 \text{ [mm]}$$

where,

t, p, R_o and σ are as defined in Sec.1.

2.7.5.5.2 The inside radius of dishing and flanging are to be as required by 2.7.5.3.

2.7.5.6 Dished and flanged ends for unsupported vertical boiler furnaces:

2.7.5.6.1 The minimum thickness, t, of dished and flanged ends for vertical boiler furnaces that are subject to pressure on the convex side and are without support from stays of any kind, is to be determined by the following formula, but is in no case to be less than the thickness of the firebox:

$$t = \frac{C\,p\,R_o}{660} + 0.75 \text{ [mm]}$$

where,

t and p are as defined in Sec.1;

R_o = outside radius of the crown plate, in [mm], (in no case Ro/t to exceed 88);

C = $\frac{2x}{x+\sigma}$ or 0.85 whichever is greater

x = specified minimum 0.2 per cent proof stress in [N/mm^2], at a temperature 90°C above the saturated steam temperature corresponding to the design pressure for carbon and carbon-manganese steel with a specified minimum tensile strength of 400 [N/mm^2];

σ = specified minimum 0.2 per cent proof stress in [N/mm^2], at a temperature 90°C above the saturated steam temperature corresponding to the design pressure for the steel actually used.

2.7.5.6.2 The inside radius of curvature, R_i, see Fig.2.3.1.2 (a), of the end plate is to be not greater than the external diameter of the cylinder to which it is attached.

2.7.5.6.3 The inside knuckle radius, r_i, see Fig.2.3.1.2 (a), of the arc joining the cylindrical flange to the spherical surface of the end is to be not less than four times the thickness of the end plate and in no case less than 65 [mm].

2.7.6 Cylindrical furnaces subject to external pressure

2.7.6.1 Maximum thickness

2.7.6.1.1 Furnaces, plain or corrugated, are not to exceed 22.5 [mm] in thickness.

2.7.6.2 Corrugated furnaces

2.7.6.2.1 The minimum thickness, t, of corrugated furnaces is to be determined by the following formula:

$$t = \frac{P\,D_o}{C} + 0.75\ [\mathrm{mm}]$$

where,

p is as defined in Sec.1;

D_o = external diameter of the furnace measured at the bottom of the corrugations [mm];

t = thickness, of the furnace plate measured at the bottom of the corrugations [mm];

C = 1060 for Fox, Morision and Deighton corrugations;

= 1130 for suspension and bulb corrugations.

2.7.6.3 Plain furnaces, flue sections and combustion chamber bottoms

2.7.6.3.1 The minimum thickness, t, of plain furnaces or furnaces strengthened by stiffening rings, of flue sections and of the cylindrical bottoms of combustion chambers is to be determined by the following formulae, the greater of two thicknesses being taken:

$$t = \sqrt{\frac{p\,D_o\,(L + 160)}{102400}} + 0.75\ [\mathrm{mm}]$$

$$t = \frac{CpD_o}{1100} + \frac{L}{320} + 0.75\ [\mathrm{mm}]$$

where,

t and p are as defined in Sec.1;

D_o = external diameter of the furnace, flue or combustion chamber [mm];

L = length of section between the center of points of substantial support [mm];

$$C = \frac{2x}{x + \sigma}$$

where,

x and σ are as defined in 2.7.5.6.

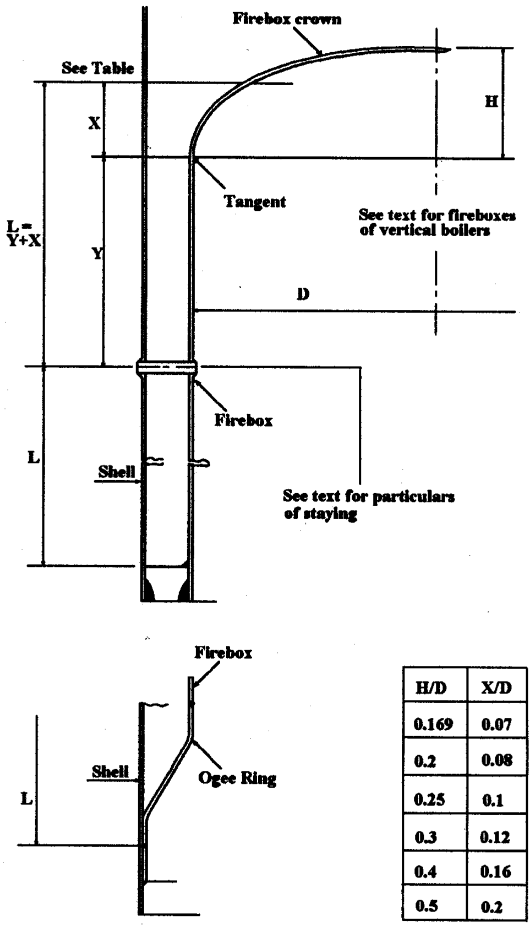
2.7.6.4 Plain furnaces of vertical boilers

2.7.6.4.1 The thickness of plain furnaces not exceeding 1700 [mm] in external diameter is to be determined by the formulae given in 2.7.6.3.1, the greater of the two thicknesses being taken;

where,

D = external diameter of the furnace, in [mm]; where the furnace is tapered, the diameter is to be the mean of that at the top and that at the bottom where it meets substantial support from flange, ring or row of stays;

L = effective length, in [mm], of the furnace between the points of substantial support as indicated in Fig.2.7.6.4.1.



H/D	X/D
0.169	0.07
0.2	0.08
0.25	0.1
0.3	0.12
0.4	0.16
0.5	0.2

Fig. 2.7.6.4.1 : Effective length, L

2.7.6.4.2 For furnaces under 760 [mm] in external diameter, the thickness is to be not less than 8 mm, and for furnaces 760 [mm] in external diameter and over, the thickness is to be not less than 9.5 [mm]. Furnaces exceeding 1700 [mm] in external diameter will be subject of special consideration.

2.7.6.4.3 A circumferential row of stays connecting the furnace to the shell will be considered to provide substantial support to the furnace, provided that:

a) the diameter of the stay is not less than 22.5 [mm] or twice the thickness of the furnace, whichever is the greater. In case of screwed stays the diameter is to be measured over the threads;

b) the pitch of the stays at the furnace does not exceed 14 times the thickness of the furnace.

2.7.6.5 Hemispherical furnaces

2.7.6.5.1 The minimum thickness, t, of unsupported hemispherical furnaces subject to pressure on convex surface is to be determined by the following formula:

$$t = \frac{CpR_o}{608} + 0.75 \text{ [mm]}$$

where,

t and p are as defined in Sec.1;

R_o = outer radius of curvature of furnace [mm];

$C = \frac{2x}{x + \sigma}$ or 0.85, whichever is greater

where,

x and σ are as defined in 2.7.5.6.

2.7.6.5.2 In no case is the minimum thickness to exceed 22.5 mm, or the ratio $\frac{R_o}{(t - 0.75)}$ to exceed 100.

2.7.6.6 Ogee rings

2.7.6.6.1 The minimum thickness, t, of the ogee ring which connects the bottom of the furnace to the shell of a vertical boiler and sustains the whole vertical load on the furnace is to be determined by the following formula:

$$t = \sqrt{\frac{p\,D_i(D_i - D_o)}{9000}} + 0.75 \text{ [mm]}$$

where,

t and p are as defined in Sec.1;

D_i = inside diameter of boiler shell [mm];

D_o = outside diameter of lower part of the furnace where it joins the ogee ring [mm].

2.7.6.7 Uptakes of vertical boiler

2.7.6.7.1 The minimum thickness, t, of internal uptakes of vertical boiler is to be determined by the following formulae, the greater of the two thicknesses being taken:

$$t = \sqrt{\frac{p\,D_o(L + 610)}{102400}} + 4 \text{ [mm]}$$

$$t = \frac{pD_o}{1100} + \frac{L}{320} + 4 \text{ [mm]}$$

where,

t and p are as defined in Sec.1;

D_o = external diameter of uptake [mm];

L = length of uptake between the centers of points of substantial support [mm].

2.7.7 Stay tubes and bar stays for cylindrical boilers

2.7.7.1 Stay tubes

2.7.7.1.1 Each stay tube is to be designed to carry its due proportion of the load on the plates which it supports. No stay tube is to be less than 5 [mm] thick at its thinnest part.

2.7.7.1.2 The thickness of stay tubes welded to the tube plates is to be such that the maximum stress on the thinnest part of the tube does not exceed 69 [N/mm^2].

2.7.7.1.3 Welded-in stay tubes are to be expanded into tube plate in addition to welding.

2.7.7.1.4 Stay tubes may be welded into the boiler after stress relief, provided they are not adjacent in the same tube nest.

2.7.7.2 Combustion chamber and longitudinal bar stays.

2.7.7.2.1 The permissible stress in combustion chamber and other similar bar stays, calculated on minimum sectional area, is not to exceed 62 [N/mm^2].

2.7.7.2.2 The diameter of any stay is to be not less than 19 [mm].

2.7.7.2.3 The permissible stress in longitudinal stays, calculated on the minimum cross-sectional area, is not to exceed:

$$\frac{\text{minimum specified tensile strength } [\text{N/mm}^2]}{5.3}$$

2.7.7.2.4 In no case is the diameter of the longitudinal stays at any section to be less than 25 [mm].

2.7.7.3 Loads on stay tubes and bar stays

2.7.7.3.1 Stay tubes and bar stays are to be designed to carry the whole load due to pressure on the area to be supported.

2.7.7.3.2 For a stay tube or bar stay, the net area to be supported is to be the area [mm^2], enclosed by the lines bisecting at right angles the lines joining the stay and the adjacent points of support, less the area of any tubes or stays embraced. In the case of a stay tube or bar stay in the boundary rows, the support afforded by the flat plate margin, where applicable, should be taken into account.

2.7.7.3.3 Where there are no stay tubes in the tube nest, the area to be supported by a bar stay is to extend to the tangential boundary of the tube nest.

2.8 Access arrangements

2.8.1 General

2.8.1.1 All pressure vessels are to be so made that the internal surfaces may be examined. Wherever practicable, the openings for this purpose are to be sufficiently large for access and for cleaning the inner surfaces.

2.8.1.2 Manholes in cylindrical shells should preferably have their shorter axes arranged longitudinally, and are to be located clear of the welded joints in the shell.

2.8.1.3 Doors for manholes and sightholes are to be formed from steel plate or of other approved construction, and all jointing surfaces are to be machined.

2.8.1.4 Doors of the internal type are to be provided with spigots which have a clearance of not more than 1.5 [mm] all round, i.e. the axes of the opening are not to exceed those of the door by more than 3 [mm].

2.8.1.5 Doors of the internal type for openings not larger than 230 x 180 [mm] need be fitted with only one stud, which may be forged integral with the door. Larger doors are to be provided with two studs screwed through the door and fitted with nuts on the inside. Alternatively, bolts may be used, screwed through the door with the heads inside. Other methods of attachment may be accepted, provided that details are submitted for consideration.

2.8.1.6 The crossbars or dogs for doors are to be of steel.

2.8.1.7 Circular flat cover plates may be fitted to raised circular manhole frames not exceeding 400 [mm] diameter, and for an approved design pressure not exceeding 18 bar. Thickness of the frames are to be not less than 19 [mm] in all parts. The circular cover plates and joint flanges for such frames are to be not less than:-

a) 25 [mm] thick for an approved design pressure: ≤ 8.6 bar;

b) 29 [mm] thick for an approved design pressure: > 8.6 bar ≤ 14.5 bar;

c) 32 [mm] thick for an approved design pressure: > 14.5 bar ≤ 18 bar.

2.8.1.8 The cover plates are to be provided with spigots and are to be secured by at least 16 bolts not less than 25 [mm] diameter, so that the stress in the bolts at the root of the thread due to pressure does not exceed:

- 34 [N/mm^2] for 25 [mm] diameter bolts
- 41 [N/mm^2] for 28 [mm] diameter bolts
- 45 [N/mm^2] for 32 [mm] diameter bolts

2.8.1.9 For the purpose of calculation, the pressure may be assumed to act on the whole area within the pitch circle of the bolts.

2.8.1.10 For smaller circular openings in headers and similar fittings, an approved type of plug may be used.

2.8.2 Additional requirements for boilers, superheaters, economizers, and similar vessels

2.8.2.1 In water tube boilers, manholes are to be provided in all drums of sufficient size to allow access for internal examinations and cleaning and for fitting and expanding the tubes. In the case of headers for water walls, superheaters or economizers, and of drums which are too small to permit entry, sight holes or mudholes sufficiently large and numerous for these purposes are to be provided.

2.8.2.2 Cylindrical boilers are to be provided, where possible, with means for ingress to permit examination and cleaning of the inner surfaces of plates and tubes exposed to flame. Where the boilers are too small to permit this there are to be sightholes and mudholes sufficiently large and numerous to allow the inside to be satisfactorily cleaned.

2.8.2.3 Where the cross tubes of vertical boilers are large, there is to be a sight hole in the shell opposite to one end of each tube sufficiently large to allow the tube to be examined and cleaned. These sight holes are to be in positions accessible for that purpose.

2.9 Shell type exhaust gas heated economizers that may be isolated from the steam plant system

2.9.1 Scope

2.9.1.1 This requirement is applicable to shell type exhaust gas heated economizers that are intended to be operated in a flooded condition and that may be isolated from the steam plant system and intended to be fitted on board ships contracted for construction on or after 1 January 2007.

2.9.2 Design and construction

2.9.2.1 Design and construction of shell type economizers are to pay particular attention to the welding, heat treatment and inspection arrangements at the tube plate connection to the shell.

2.9.2.2 Every shell type economizer is to be provided with a means of indicating the internal pressure and to be located so that the pressure can be easily read from a position from which the pressure may be controlled.

2.9.2.3 Every shell type economizer is to be provided with removable lagging at the circumference of the tube end plates to enable ultrasonic examination of the tube plate to shell connection.

2.9.3 Feed water

2.9.3.1 Every economizer is to be provided with arrangements for pre-heating and de-aeration, addition of water treatment or combination thereof to control the quality of feed water to within the manufacturer’s recommendations.

2.9.4 Operating instructions

2.9.4.1 The manufacturer is to provide operating instructions for each economizer and is to include reference to:

- Feed water treatment and sampling arrangements.
- Operating temperatures – exhaust gas and feed water temperatures.
- Operating pressure.
- Inspection and cleaning procedures.
- Records of maintenance and inspection.

- The need to maintain adequate water flow through the economizer under all operating conditions.

- Periodical operational checks of the safety devices to be carried out by the operating personnel and to be documented accordingly.

- Procedures for using the exhaust gas economizer in the dry condition.

- Procedures for maintenance and overhaul of safety valves.

Section 3

Fittings and Mountings

3.1 General

3.1.1 All valves over 38 [mm] diameter are to be fitted with outside screws, and the covers are to be secured by bolts or studs. All valves are to be arranged to shut with a right-hand (clockwise rotation) motion of the wheels.

3.1.2 Construction and arrangement of valves and cocks are to be such that it can be seen without difficulty whether they are open or shut, preferably by fitting a suitable indicator.

3.1.3 Where boiler mountings are secured by studs, the studs are to have a full thread holding in the plate for a length of at least one diameter. If the stud hole penetrates the whole thickness of the plate, the stud is to be screwed right through the plate and is to be fitted with a nut inside the boiler. Where bolts are used for securing mountings, they are to be screwed right through the plate with their heads inside the boiler.

3.1.4 Safety valve chests and other boiler and superheater mountings subject to pressures exceeding 10.3 bar or to steam temperatures exceeding 218°C, and boiler blow-down fittings, are to be made of steel or other approved material.

3.1.5 Adequate arrangements are to be provided for draining and venting the separate parts of each pressure vessel.

3.2 Safety valves

3.2.1 For boilers and steam generators

3.2.1.1 Boilers and steam generators are to be fitted with not less than two safety valves, each having a minimum internal diameter of 25 [mm], but those having a total heating surface of less than 50 [m^2] may have one valve not less than 50 [mm] diameter.

3.2.1.2 The valves, spindles, springs and compression screws are to be so encased and locked or sealed that the safety valves and pilot valves after setting to the working pressure, cannot be tampered with or overloaded in service. The spring casing of superheater safety valves should be ventilated, or other arrangements provided to protect the springs from excessive temperature.

3.2.1.3 Valves are to be so designed that in the event of fracture of springs they cannot lift out of their seats.

3.2.1.4 Easing gear is to be provided for lifting the safety valves and is to be operable by mechanical means at a safe position from the boiler or engine room platforms.

3.2.1.5 Safety valves are to be made with working parts having adequate clearances to ensure complete freedom of movement.

3.2.1.6 Valve seats are to be effectively secured in position. Any adjusting devices which control discharge capacity are to be positively secured so that the adjustment will not be affected when the safety valves are dismantled at surveys.

3.2.1.7 All the safety valves of each boiler and steam generator may be fitted in one chest, which is to be separate from any other valve chest and is to be connected directly to the shell by a strong and stiff neck, the passage through which is to be of cross-sectional area not less than the aggregate area of the safety valves in the chest in case of full lift valves, and one half of that area in case of other valves.

3.2.1.8 Each safety valve chest is to be drained by a pipe fitted to the lowest part and led with a downward gradient to the bilges or to a tank, clear of the boilers. No valves or cocks are to be fitted to these drain pipes. It is recommended that the bore of the drain pipes be not less than 19 [mm].

3.2.1.9

a) Where a shell type economizer is capable of being isolated from the steam plant system, it is to be provided with at least one safety valve and when it has a total heating surface of 50 [m^2] or more, it is to be provided with at least two safety valves.

b) To avoid the accumulation of condensate on the outlet side of safety valves, the discharge pipes and/or safety valve housings are to be fitted with drainage arrangements from the lowest part and led with a downward gradient to the bilges or to a tank, clear of the economizer, where it will not pose threat to either personnel or machinery.

3.2.1.10 Full details of the proposed arrangements to satisfy 3.2.1.9(a) to 3.2.1.9(b) are to be submitted for approval.

3.2.1.11 In case of watertube boilers, each saturated steam drum and each superheater are to be provided with at least one safety valve.

3.2.1.12 When a boiler is fitted with an integral superheater without any intervening stop valve, the safety valve(s) on the superheater may be considered as boiler safety valve(s). The safety valves are to be so proportioned and positioned that when relieving, sufficient steam is forced through the superheater to prevent damage to the heater.

Where a superheater, reheater or economizer is fitted with a valve between one of these and the boiler, the unit is to have appropriate safety valves. Such safety valves are not to be regarded as safety valves for the boiler.

3.2.1.13 Where it is impracticable to attach safety valves directly to the superheater, the valves are to be located as near as possible thereto and fitted to a branch piece connected to the superheater outlet pipe.

3.2.1.14 In high temperature installations the drains from safety valves are to be led to a tank or other place where high temperature steam can be safely discharged.

3.2.1.15 The designed discharge capacities of the safety valves on each boiler and steam generators are to be found from the following formulae :

Saturated steam safety valves

$$E = \frac{AC(p + 1.03)}{98.1}$$

Superheated steam safety valves

$$E = \frac{AC(p + 1.03)}{98.1}\sqrt{\frac{v_s}{v_h}}$$

where,

E = the maker's specified peak load evaporation, in [kg/hour] (including all evaporation from waterwalls, integral, or steaming economizers and other heating surfaces in direct communication with the boiler). In no case is the designed evaporation to be based on less than 29 [kg/m^2] hour of heating surface for fired boiler and 14.5 [kg/m^2] hour for exhaust gas heated boilers;

A = for ordinary, high lift or improved high lift safety valves, the aggregate area, in [mm^2], of the orifices through the seatings of the valves, neglecting the area of guides and other obstructions;

= for full lift safety valves, the net aggregate area, in [mm^2], through the seats after deducting the area of the guides or other obstructions when fully lifted;

C = 4.8 for valves of ordinary type, having a minimum lift of D/24;

= 7.2 for valves of high lift type, having a minimum lift of D/16;

= 9.6 for valves of improved high lift type having a minimum lift of D/12;

= 19.2 for valves of full lift type having a minimum lift of D/4;

D = bore of valve seat [mm];

p = design pressure, in bar;

= specific volume of saturated steam [m^3/kg];

V_h = specific volume of superheated steam [m^3/kg].

3.2.1.16 When the discharge capacity of a safety valve of approved design has been established by type tests, carried out in the presence of the Surveyors or by an independent authority recognized by IRS, on valves representative of the range of sizes and pressures intended for marine application, consideration will be given to the use of a constant higher than C=19.2, based on 90 per cent of the measured capacity up to a maximum of C = 45 for full lift safety valves.

3.2.1.17 Where boilers are not fitted with superheater, the safety valves are to be set to open at a pressure of not more than 3 per cent above the approved design pressure, and in no case at a pressure higher than :

a) the design pressure of the steam piping; or

b) the least sum of the design pressure of the machinery connected to the boiler and the pressure drop in the piping between this machinery and the boiler.

3.2.1.18 Where boilers are fitted with superheaters, the safety valves on the superheaters are to be set to a pressure not higher than :

a) the design pressure of the steam piping; or

b) the least sum of the design pressure of the machinery connected to the boiler and the pressure drop in the piping between this machinery and the boiler.

The safety valves on the boiler drum are to be set to a pressure not less than the superheater valve setting plus 0.35 bar plus the pressure drop through the superheater, when the boiler stop valves are closed and the superheater safety valves are relieving at their rated capacity. In no case, however, are the safety valves to be set to a pressure higher than 3 per cent above the design pressure of the boiler.

3.2.1.19 Tests for accumulation of pressure are to be carried out. The boiler pressure is not to rise more than 10 per cent above the design pressure, when the boiler stop valves are closed under full firing conditions. The duration of the accumulation test is to be 15 minutes for smoke-tube boilers and 7 minutes for water-tube boilers. During this test, no more feed water is to be supplied than is necessary to maintain a safe working water level.

3.2.1.20 For ordinary, high lift and improved high lift type valves, the cross-sectional area of the waste steam pipe and passages leading to it is to be at least 10 per cent greater than the aggregate area of the safety valves as used in the formulae in 3.2.1.15. For full lift and other approved valves of high discharge capacity, the cross-sectional area of the waste steam pipe and passages is to be not less than 0.1C times the aggregate valve area.

3.2.1.21 The cross-sectional area of the main waste steam pipe is to be not less than the combined cross-sectional areas of the branch waste steam pipes leading thereto from the boiler safety valves. In case of water tube boilers, each boiler should have a separate waste steam system to atmosphere.

3.2.1.22 Waste steam pipes are to be led to the atmosphere and are to be adequately supported and provided with suitable expansion joints, bends or other means to relieve the safety valve chests of undue loading.

3.2.1.23 The scantlings of waste steam pipes and silencers are to be suitable for the maximum pressure to which the pipes may be subjected in service, and in any case not less than 10.0 bar.

3.2.1.24 Silencers fitted to waste steam pipes are to be so designed that the clear area through the baffle plates is not less than that required for pipes.

3.2.1.25 The safety valves of each exhaust gas heated economizer/and each exhaust gas heated boiler which may be used as an economizer are to be provided with entirely separate waste steam pipes.

3.2.1.26 External drains and exhaust steam vents to atmosphere are not to be led to waste steam pipes.

3.2.1.27 It is recommended that a scale trap and means for cleaning be provided at the base of each waste steam pipe.

3.2.1.28 In installations operating with a high degree of superheat, consideration is to be given to the high temperatures which waste steam pipes, silencers and surrounding spaces will attain when the superheater safety valves are blowing during accumulation tests and in service. Adequate protection against heat effects is to be provided to Surveyor's satisfaction.

3.2.1.29 Waste steam pipes are to be led well clear of electric cables and any parts or structures sensitive to heat or likely to distort, the pipes are to be insulated where necessary.

3.2.2 For pressure vessels other than boilers and steam generators

3.2.2.1 Each pressure vessel system or each pressure vessel which can be isolated, is to be provided with arrangements to prevent overpressure.

3.2.2.2 Pressure vessels intended to operate completely filled with liquid are to have a liquid relief valve unless otherwise protected against overpressure.

3.2.2.3 Where a pressure vessel is fitted with heating coils, and fracture in the coils may increase the normal pressure of fluid in the pressure vessel, the relieving capacity of the safety device is to be sufficient to take into account the fracture of one tube.

3.2.2.4 The total capacity of the safety valves, fitted to any pressure vessel or system of pressure vessels, is to be sufficient to discharge the maximum quantity of fluid (liquid or gaseous) that can be generated or supplied without causing a rise in the pressure of more than 10 per cent above the design pressure.

3.2.2.5 The safety valves are to be set to open at a pressure of not more than 3 per cent above the design pressure.

3.2.2.6 The use of bursting discs or a combination of bursting discs and safety valves instead of safety valves is subject to special consideration in each case.

3.2.2.7 The discharge from safety valves is to be led to a place where no hazard will be created by the contents being discharged.

3.2.2.8 Where a gas is used for fire extinguishing in the machinery spaces, the discharge from safety valves or fusion plugs on air receivers is to be led to open deck outside machinery spaces, alternatively, the quantity of gas for fire fighting purposes is to be increased to such an extent that the efficiency of the fire extinguishing installation is not affected.

3.3 Stop valves

3.3.1 Boilers and steam generators

3.3.1.1 One main stop valve is to be fitted to each boiler and located as near the boiler as practicable. There are to be as few auxiliary stop valves as possible so as to avoid piercing the boiler shell than is absolutely necessary.

3.3.1.2 Where two or more boilers are connected together :

a) the steam connections for each boiler are to be provided with two stop valves with a drain connection between them. The valve nearest to the boiler is to be a non-return valve;

b) essential services are to be capable of being supplied from at least two boilers.

3.3.2 Pressure vessels other than boilers and steam generators

3.3.2.1 Each pressure vessel or system is to be fitted with a stop valve situated as close as possible to the shell.

3.4 Water level indicators

3.4.1 Every boiler and steam-heated steam generator is to be fitted with at least two independent means of indicating the water level in it, one of which is to be a gauge glass. The other means is to be either an additional gauge glass or an approved equivalent device.

3.4.2 Where a steam and water drum exceeding 4 [m] in length is fitted athwartships, two gauge glasses are to be fitted in suitable positions, one near each end of the drum.

3.4.3 The water gauges are to be readily accessible and placed so that the water level is clearly visible. The lowest visible part of the glass of the water gauge is to be situated at the lowest safe working water level.

a) In the case of water-tube boilers, the water gauge glasses are to be located so that water is just showing when the water level in the steam drum is just above the top row of tubes when the boiler is cold (generally about 25 [mm] above).

b) In water-tube boilers, the tubes of which are not entirely drowned when cold, the water gauge glasses are to be placed, to the Surveyor's satisfaction, in the positions which have been found by experience to indicate satisfactorily that the water content is sufficient for safety when the boiler is worked under all service conditions.

c) The level of the highest part of the effective heating surfaces, e.g. combustion chamber top of a horizontal boiler and the furnace crown of a vertical boiler, is to be clearly marked in a position adjacent to the water gauge glass.

3.4.4 The length of the water gauge glasses is to be sufficient for verifying the water levels in case of alarm and oil supply cut-off.

3.4.5 The cocks of all water gauges are to be operable from positions free from danger in the event of the glass breaking.

3.4.6 If the water gauges are not fitted directly to the shell of the boiler, but to stand pillars or columns, it is desirable that these pillars or columns should be bolted directly to the shell of the boiler. If they are connected to the boiler by means of pipes, the pipes are to be fitted with terminal cocks, not valves, secured direct to the boiler shell.

a) For boilers exceeding 3 [m] in diameter, the pillars are to be not less than 63 mm, and the connecting pipes not less than 38 [mm] internal diameter. For boilers exceeding 2.3 [m] but not exceeding 3 [m] in diameter, the pillars are to be not less than 50 [mm] and the pipes not less than 32 [mm] internal diameter.

b) The upper ends of the connecting pipes are to be so arranged that there is no pocket or bend where an accumulation of water from the condensation of the steam can lodge. They should not pass through the uptake if they can be otherwise arranged. If, however, this condition cannot be complied with, they may pass through it by means of a passage at least 50 [mm] clear of the pipe all round, open for ventilation.

3.5 Low water level fuel shut-off and alarm

3.5.1 Each fired boiler is to be fitted with a system of water level detection which is to be independent of any other mounting on the boiler and which will operate audible and visible alarms and shut-off automatically the fuel supply to the burners when the water level falls to a predetermined low level.

3.6 Feed check valves

3.6.1 Each main boiler or auxiliary boiler for essential services and each steam-heated steam generator is to have two independent feed pipes; each feed pipe is to be provided with two feed check valves. Boiler heated exclusively by exhaust gases may have only one feed pipe and with one feed check valve.

3.6.2 The feed check valves are to be attached, wherever practicable, direct to the boiler, but where the arrangements necessitate the use of standpipes between the boiler and the check valves, these pipes are to be of steel or other approved material. For boiler feed water systems, See Ch.3, Sec.6.

3.6.3 In boilers, where economizer forms an integral part of the boiler, and where the arrangements necessitate the use of a common inlet pipe on the economizer for both main and auxiliary feed systems, this pipe is to be as short as practicable, and the arrangement of check valves is to be such that either feed line can be effectively isolated without interruption of the feed water supply to the boiler.

3.6.4 The feed check valves are to be fitted with efficient gearing, whereby they can be satisfactorily worked from the stokehold floor, or other convenient position.

3.6.5 Standpipes on boiler, for feed inlet, are to be designed with an internal pipe to prevent direct contact between the feed pipe and the boiler shell or end plates with the object of minimizing thermal stresses in these plates. Similar arrangements are to be provided for desuperheater and other connections, where significant temperature difference occur in service.

3.7 Pressure gauges

3.7.1 Each boiler and superheater is to be provided with a steam-pressure gauge.

3.7.2 The pressure gauges are to be placed where they are easily read. The highest permissible working pressure is to be marked off on pressure gauge in red.

3.8 Blow-down and scum valves

3.8.1 Each boiler is to be fitted with at least one blow-down valve secured to the lower part of the boiler.

3.8.2 Where it is not practicable to attach the blow-down valve direct to water-tube boilers, the valve may be placed immediately outside the boiler casing with a steel pipe of substantial thickness fitted between the boiler and valve. The pipe and valve are to be suitably supported and any pipe which may be exposed to direct heat from the furnace is to be adequately protected.

3.8.3 The blow-down valve and its connections to the sea need not be more than 38 [mm], and is to be not less than 19 [mm] internal diameter. For cylindrical boilers the size of the valve may be generally 0.0085 times the diameter of the boiler.

3.8.4 Blow-down valves and scum valves (where the latter are fitted) of two or more boiler may be connected to one common discharge, but where thus arranged there are to be screw-down non- return valves fitted for each boiler to prevent the possibility of the contents of one boiler passing to another.

3.8.5 The blow-down cock or valve on the ship's side is to be fitted in a readily accessible position, above the level of the floor plates, and is to be arranged such that it can be readily seen whether it is open or shut. The cock handle is not to be removable unless the cock is shut, and if a valve is fitted, the wheel is to be fixed to the spindle.

3.9 Salinometer valve or cock

3.9.1 Each boiler is to be provided with a salinometer valve or cock secured direct to the boiler in a convenient position. The valve or cock is not to be on the water gauge standpipe.

Section 4

Hydraulic Tests

4.1 Boilers (fired and exhaust gas heated), economizers, superheaters, reheaters, steam receivers, steam heated generators and similar vessels

4.1.1 General

4.1.1.1 Boilers and pressure vessels, together with their components are to withstand the following hydraulic tests without any sign of weakness or defect.

4.1.1.2 Having regard to the variation in the types and design of boilers, the hydraulic test may be carried out by either of the methods indicated below:

a) Boilers are to be tested on completion to a pressure 1.5 times the approved design pressure; or

b) Where construction permits, all components of the boiler are to be tested on completion of the work including heat treatment to 1.5 times the design pressure. In the case of components such as drums or headers, which are to be drilled for tube holes, the test may be made before drilling the tube holes, but is to be after the attachment of standpipes, stubs and similar fittings and also after heat treatment has been carried out. Where all the components have been tested as above, each completed boiler after assembly is to be tested to 1.25 times the design pressure.

4.1.2 Mountings

4.1.2.1 All boiler mountings are to be subjected to a hydraulic test of twice the approved design pressure with the exception of feed check valves and other mountings connected to the main feed system which are to be tested to 2.5 times the approved boiler design pressure, or twice the maximum pressure which can be developed in the feed line in normal service, whichever is greater.

4.2 Other pressure vessels

4.2.1 General

4.2.1.1 Pressure vessels are to be tested on completion to a pressure, p_t, determined by the following formula, without showing signs of weakness or defect :-

$$p_t = 1.3 \frac{\sigma_{50}}{\sigma T} \frac{t}{t - 0.75} p$$

but in no case is to exceed 1.5 $\frac{t}{t - 0.75} p$

where,

p_t = test pressure, in bar

p = design pressure, in bar

t = nominal thickness of shell as indicated on the plan [mm]

σ_{50} = allowable stress at 50°C [N/mm^2]

σT = allowable stress at design temperature [N/mm^2].

4.2.2 Mountings

4.2.2.1 Mountings are to be subjected to a hydraulic test of twice the approved design pressure.

End of Chapter

Chapter 6

Steering Gear

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter apply to the design and construction of steering gear.

1.1.2 Whilst the requirements of this Chapter are considered to meet the relevant regulations of the Safety of Life at Sea 1974 and applicable amendments, attention should be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

1.1.3 Consideration will be given to other cases, or to other arrangements which are equivalent to those required by the Rules.

1.2 Definitions

1.2.1 **Steering gear control systems** means the equipment by which orders are transmitted from the navigating bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

1.2.2 **Main steering gear** means the machinery, rudder actuator(s), the steering gear power units, if any, and ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions.

1.2.3 **Steering gear power unit** means :

a) in the case of electric steering gear, an electric motor and its associated electrical equipment;

b) in the case of electrohydraulic steering gear, an electric motor and its associated electrical equipment and connected pump;

c) in the case of other hydraulic steering gear, a driving engine and connected pump.

IR1.2.3 For the purposes of non-traditional steering arrangements such as azimuthing propellers, waterjets, etc, the above definitions may be applied as appropriate. The steering gear power unit relates to the equipment for changing the direction of thrust and does not include those for generating the thrust.

1.2.4 **Auxiliary steering gear** means the equipment other than any part of the main steering gear necessary to steer the ship in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose.

1.2.5 **Power actuating system** means the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with associated pipes and fittings, and a rudder actuator. The power actuating systems may share common mechanical components, i.e. tiller, quadrant and rudder stock, or components serving the same purpose.

1.2.6 **Maximum ahead service speed** means the greatest speed which the ship is designed to maintain in service at sea at her deepest seagoing draught.

1.2.7 **Rudder actuator** means the component(s) which converts directly hydraulic pressure into mechanical action to move the rudder.

1.2.8 **Maximum working pressure** means the expected pressure in the system when steering gear is operated to comply with 2.1.2(b).

1.2.9 **Declared steering angle limits** in the case of non-traditional steering arrangements such as azimuthing propellers, waterjets, etc. are the operational limits in terms of maximum steering angle, or equivalent, according to manufacturers guidelines for safe operation, also taking into account the vessel’s speed or propeller torque/speed or other limitation. The "declared steering angle limits" are to be declared by the directional control system manufacturer for each ship specific non-traditional steering mean. Ship's manoeuvrability tests, such as Res. MSC.137(76) are to be carried out with steering angles not exceeding the declared steering angle limits.

1.3 Installation

1.3.1 The steering gear is to be secured to the seating by fitted bolts, and suitable chocking arrangements are to be provided. The seating is to be of substantial construction.

1.4 Steering gear compartment

1.4.1 The steering gear compartment is to be :

a) Readily accessible and, as far as practicable separated from machinery spaces;

b) Provided with suitable arrangements to ensure working access to steering gear machinery and controls. These arrangements are to include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

1.5 Plans

1.5.1 Before starting construction, all relevant plans and specifications are to be submitted for approval in triplicate.

1.5.2 These plans should give details of scantlings and materials of the steering gear together with proposed rated torque and all relief valve settings.

1.6 Materials

1.6.1 All the steering gear components the rudder stock and/or components of other steering arrangements for directional control are to be of sound and reliable construction to the Surveyor's satisfaction of IRS.

1.6.2 All components transmitting mechanical forces to the rudder stock are to be tested according to the requirements of Pt.2.

1.6.3 Ram; cylinders; pressure housing of rotary vane type actuators; hydraulic power piping; valves; flanges and fittings; and all steering gear components transmitting mechanical forces to the rudder stock (such as tillers, quadrants, or similar components) are to be of steel or other approved ductile material, duly tested in accordance with the requirements of Pt.2. In general, such material is not to have an elongation of less than 12 per cent nor a tensile strength in excess of 650 [N/mm^2]. The use of ductile (nodular) iron castings will be acceptable provided the material has an elongation of not less than 12 per cent.

1.7 Rudder, rudder stock, vanes, tiller and quadrant

1.7.1 For the requirements regarding rudder, rudder stock, See Pt.3, Ch.14.

1.7.2 All components transmitting mechanical forces to the rudder stock are to have a strength of at least equivalent to the rudder stock in way of the tiller. The resultant equivalent stress, σ_e, caused by the transmission of rudder torque, Qr, in tillers, vanes and other power transmitting components is not to exceed 118/k [N/mm^2], i.e.

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \leq 118/\mathrm{k} \ \ [\mathrm{N/mm^2}]$$

where,

σ_e = The combined equivalent stress, [N/mm^2]

σ = The bending stress, [N/mm^2]

τ= The torsional shear stress, [N/mm^2]

k = Material factor for the component under consideration as defined in Pt.3, Ch.14, Sec.1;

Q_r = The rudder torque calculated as per Pt.3, Ch.14, Sec.3.2 [N-m].

1.7.3 The section modulus 'Z' [cm^3] and the sectional area 'A' [cm^2] of the tiller arms is not to be less than the following:

$$\mathrm{Z} = 0.012\,\mathrm{Q}_r \left(1 - \frac{\mathrm{x}}{\mathrm{R}}\right)\mathrm{k} \ \ [\mathrm{cm}^3]$$

$$\mathrm{A} = 2.0\frac{\mathrm{Q_r}}{\mathrm{R}} \ \mathrm{k\,x}10^{-4} \ \ [\mathrm{cm}^2]$$

where,

R = The distance [m] from the point of application of the effort on the tiller to the centre of rudder stock; and

x = The distance [m] from the section under consideration to the centre of the rudder stock.

1.7.4 The boss may be fitted on the rudder stock by shrinking with/without key or may be of the split type. The ratio between the mean of outer and inner diameters of the boss is to be not less than 1.75 and the height of the boss is not to be less than the inner diameter of the boss.

1.7.5 Co-efficient of friction for shrink fitting is to be taken as specified in Pt.3, Ch.14, Sec.6.3.

1.7.6 In case of split type boss, the total number of joining bolts is to be at least 4. The distance of the centre of the bolts from the centre of the rudder stock is generally to be 1.15du and the thickness of the coupling flange is to be at least 1.1 times the required bolt diameter. The thickness of shim to be fitted between two halves before machining is to be 0.0015du. The diameter of the coupling bolt, d_b is to be not less than :

$$\mathrm{d_b} = 0.60\frac{\mathrm{du}\sqrt{\mathrm{k}}}{\sqrt{(\mathrm{nks})}} \ \ [\mathrm{mm}]$$

where,

du = The rudder stock diameter [mm] in way of the tiller calculated in accordance with Pt.3, Ch.14, Sec.5;

n = Total number of joining bolts.

k = Material factor for the bolts.

ks = Material factor for the rudder stock material.

1.7.7 The dimensions of the key are to comply with the requirements of Pt.3, Ch.14, Sec.6.2.

1.7.8 Where higher tensile bolts are used on bolted tillers and quadrants, the yield and ultimate tensile stresses of the bolt material are to be stated on the plans submitted for approval, together with full details of the methods to be adopted to obtain the required setting-up stress. Where patent nuts or systems are used, the manufacturer's instructions for assembly should be adhered to.

1.7.9 In bow rudders having a vertical locking pin operated from the deck above, positive means are to be provided to ensure that the pin can be lowered only when the rudder is exactly central. In addition, an indicator is to be fitted at the deck to show when the rudder is exactly central.

1.8 Mechanical steering gear

1.8.1 Steel-wire rope, chain and other mechanical systems, when these are used for rudder stock diameters of 120 [mm] and less but excluding allowance for strengthening in ice, will be specially considered. In general the breaking strength of rods/chains etc. is not to be less than:

Breaking strength = $6\frac{\mathrm{Qr}}{\mathrm{R}}$ N

Where R is defined in 1.7.3.

Section 2

Performance

2.1 Requirements for traditional type of steering gears

2.1.1 Unless the main steering gear comprises of two or more identical power units, in accordance with 2.1.4 or 8.1.1, every ship is to be provided with a main steering gear and an auxiliary steering gear in accordance with the requirements of the Rules. The main steering gear and the auxiliary steering gear are to be so arranged that the failure of one of them will not render the other one inoperative.

The rudder stock diameters mentioned in 2.1.2c), 2.1.3c) and 6.1.1 are to be taken as having been calculated for mild steel with yield strength of 235 [N/mm^2].

2.1.2 The main steering gear and rudder stock are to be :

a) Of adequate strength and capable of steering the ship at maximum ahead speed which is to be demonstrated in accordance with 7.2;

b) Capable of putting the rudder over from 35° on one side to 35° on the other side with the ship at its deepest seagoing draught and running ahead at maximum ahead service speed and under the same conditions, from 35° on either side to 30° on the other side in not more than 28 seconds;
where it is impractical to demonstrate compliance with this requirement during sea trials with the ship at its deepest seagoing draught and running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch, ships regardless of date of construction may demonstrate compliance with this requirement by one of the following methods:

1 during sea trials the ship is at even keel and the rudder fully submerged whilst running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch or

2 where full rudder immersion during sea trials cannot be achieved, an appropriate ahead speed to be calculated using the submerged rudder blade area in the proposed sea trial loading condition. The calculated ahead speed is to result in a force and torque applied to the main steering gear which is at least as great as if it was being tested with the ship at its deepest seagoing draught and running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch or

3 the rudder force and torque at the sea trial loading condition have been reliably predicted and extrapolated to the full load condition. The speed of the ship is to correspond to the number of maximum continuous revolutions of the main engine and maximum design pitch of the propeller.

c) Operated by power where necessary to meet the requirements of (b) and in any case when the Rules, excluding strengthening for navigation in ice, require a rudder stock over 120 [mm] diameter in way of the tiller (See 2.1.1); and

d) So designed that they will not be damaged at maximum astern speed; however, this design requirement need not be proved by trials at maximum astern speed and maximum rudder angle.

IR 2.1.2.1 In case of 2.1.2 b).2 ,it is to be ensured that the equivalent stress in the rudder stock due to bending and torque is not to exceed the acceptance limits given in Pt 3, Ch 14, Sec 5.

2.1.3 The auxiliary steering gear is to be :

a) Of adequate strength and capable of steering the ship at navigable speed and of being brought speedily into action in an emergency:

b) Capable of putting the rudder over from 15 on one side to 15 on the other side in not more than 60 seconds with the ship at its deepest seagoing draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater;
Where it is impractical to demonstrate compliance with this requirement during sea

trials with the ship at its deepest seagoing draught and running ahead at one half of the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch or 7 [knots], whichever is greater, ships regardless of date of construction, including those constructed before 1 January 2009, may demonstrate compliance with this requirement by one of the following methods:

1 during sea trials the ship is at even keel and the rudder fully submerged whilst running ahead at one half of the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch or 7 [knots], whichever is greater; or

2 where full rudder immersion during sea trials cannot be achieved, an appropriate ahead speed is to be calculated using the submerged rudder blade area in the proposed sea trial loading condition. The calculated ahead speed is to result in a force and torque applied to the auxiliary steering gear which is at least as great as if it was being tested with the ship at its deepest seagoing draught and running ahead at one half of the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch or 7 [knots], whichever is greater; or

3 the rudder force and torque at the sea trial loading condition have been reliably predicted and extrapolated to the full load condition; and

c) Operated by power where necessary to meet the requirements of (b) and in any case when the Rules, excluding strengthening for navigation in ice, require a rudder stock over 230 [mm] diameter in way of the tiller. (See 2.1.1).

IR 2.1.3.1 In case of 2.1.3 b).2 ,it is to be ensured that the equivalent stress in the rudder stock due to bending and torque is not to exceed the acceptance limits given in Pt 3, Ch 14, Sec 5.

2.1.4 Where the main steering gear comprises two or more identical power units, an auxiliary steering gear need not be fitted, provided that :

a) In a passenger ship, the main steering gear is capable of operating the rudder as required by 2.1.2 (b) while any one of the power units is out of operation;

b) In a cargo ship, the main steering gear is capable of operating the rudder as required by 2.1.2 (b) while operating with all power units;

c) The main steering gear is arranged so that after a single failure in its piping system or in one of the power units the defect can be isolated so that steering capability is regained.

2.1.5 Main and auxiliary steering gear power units are to be:

a) Arranged to re-start automatically when power is restored after a power failure;

b) Capable of being brought into operation from a position on the navigating bridge. In the event of a power failure to any one of the steering gear power units, an audible and visual alarm is to be given on the navigating bridge;

c) Arranged so that transfer between units can be readily effected.

2.1.6 Steering gear, other than of the hydraulic type, will be accepted provided the standards are considered equivalent to the requirements of this Section.

2.1.7 Manually operated gears are only acceptable when the operation does not require an effort exceeding 16 [kgf] under normal conditions.

2.2 Requirements for non-traditional (azimuthing propellers, waterjets, etc.) type of steering gears:

2.2.1 For a ship fitted with multiple steering systems, such as but not limited to azimuthing propulsors or water jet propulsion systems, the requirement in 2.1.1 is considered satisfied if each of the steering systems is equipped with its own steering gear.

2.2.2 The main steering arrangements for ship directional control are to be:

a) of adequate strength and capable of steering the ship at maximum ahead speed which is to be demonstrated in accordance with 7.2 (Also refer Ch.4, Sec.9);

b) capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 2.3°/s with the ship running ahead at maximum ahead service speed;

c) for all ships, operated by power;

d) so designed that they will not be damaged at maximum astern speed (Also refer Ch.4, Sec.9);

2.2.3 The auxiliary steering arrangements for ship directional control are to be:

a) of adequate strength and capable of steering the ship at navigable speed and of being brought speedily into action in an emergency:

b) capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed, of not less than 0.5°/s; with the ship running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater; and

c) for all ships, operated by power where necessary to meet the requirements of 2.2.3.b and in any ship having propulsive power of more than 2,500 kW per thruster unit.

2.2.4 Where the main steering arrangements for ship directional control comprises two or more identical power units, auxiliary steering arrangements need not be fitted, provided that:

a) In a passenger ship, the main steering arrangements are capable of operating the ship's directional control system as required by paragraph 2.2.2.b while any one of the power units is out of operation;

b) In a cargo ship, the main steering arrangements are capable of operating the ship's directional control system as required by paragraph 2.2.2.b while operating with all power units;

c) The main steering arrangements are arranged so that after a single failure in its piping or in one of the power units the defect can be isolated so that steering capability can be maintained or speedily regained.

2.2.5 In a ship fitted with multiple steering systems, such as but not limited to azimuthing propulsors or water jet propulsion systems, an auxiliary steering gear need not be fitted, provided that :

a) In a passenger ship, each of the steering systems is fitted with two or more identical power units, capable of satisfying the requirements in 2.2.2.b while any one of the power units is out of operation;

b) In a cargo ship, each of the steering systems is fitted with one or more identical power units, capable of satisfying the requirements in 2.2.2.b while operating with all power units;

c) Each of the steering systems is arranged so that after a single failure in its piping or in one of the power units, ship steering capability (but not individual steering system operation) can be maintained or speedily regained (e.g. by the possibility of positioning the failed steering system in a neutral position in an emergency, if needed).

2.2.6 Main and auxiliary steering gear power units are to be:

a) Arranged to re-start automatically when power is restored after a power failure;

b) Capable of being brought into operation from a position on the navigating bridge. In the event of a power failure to any one of the steering gear power units, an audible and visual alarm is to be given on the navigating bridge;

c) Arranged so that transfer between units can be readily effected.

2.3 Other requirements

2.3.1 Where the steering gear is so arranged that more than one power system can be simultaneously operated, the risk of hydraulic locking caused by a single failure is to be considered.

2.3.2 A means of communication is to be provided between the navigating bridge and the steering gear compartment.

2.3.3 Power-operated steering gears are to be provided with positive arrangements, such as limit switches, for stopping the gear before the rudder stops are reached. These arrangements are to be synchronized with the gear itself and not with the steering gear control.

Section 3

Construction and Design

3.1 General

3.1.1 Rudder actuators other than those covered by 8.3 and Sec.9 are to be designed in accordance with the relevant requirement of Ch.5 for Class 1 pressure vessels (notwithstanding any exemptions for hydraulic cylinders).

3.1.2 Accumulators, if fitted, are to comply with the requirements of Ch.5.

3.1.3 The welding details and welding procedures are to be approved. All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads are to be full penetration type or of equivalent strength.

3.1.4 The construction is to be such as to minimize local concentration of stress.

3.1.5 The design pressure for calculations to determine the scantlings of piping and other steering gear components subjected to internal hydraulic pressure is to be at least 1.25 times the maximum working pressure to be expected under the operational conditions specified in 2.1.2 (b) taking into account any pressure which may exist in the lower pressure side of the system. Fatigue criteria may be applied for the design of piping and components, taking into account pulsating pressures due to dynamic loads (See Sec.9).

3.1.6 The permissible primary general membrane stress is not to exceed the lower of the following values

$$\frac{\sigma B}{A} \text{ or } \frac{\sigma y}{B}$$

where,

σB = specified minimum tensile strength of material at ambient temperature

σY = specified minimum yield stress or 0.2 per cent proof stress of the material, at ambient temperature

A and B are given by the following table :

	Wrought Steel	**Cast Steel**	**Nodular Cast Iron**
A	3.5	4	5
B	1.7	2	3

3.2 Components

3.2.1 Special consideration is to be given to the suitability of any essential component which is not duplicated. Any such essential component is to, where appropriate, utilize anti-friction bearings such as ball bearings, roller bearings or sleeve bearings which are to be permanently lubricated or provided with lubrication fittings.

3.2.2 All steering gear components transmitting mechanical forces to the rudder stock, which are not protected against overload by structural rudder stops or mechanical buffers, are to have a strength at least equivalent to that of the rudder stock in way of the tiller.

3.2.3 Oil seals between non-moving parts, forming part of the external pressure boundary, should be of the metal type or of an equivalent type.

3.2.4 Oil seals between moving parts, forming part of the external pressure boundary, are to be duplicated, so that the failure of one seal does not render the actuator inoperative. Alternative arrangements providing equivalent protection against leakage may be accepted.

3.2.5 Piping, joints, valves, flanges and other fittings are to comply with the requirements of Ch.2 for Class I piping systems components. The design pressure is to be in accordance with 3.1.5.

3.2.6 Hydraulic power operated steering gears are to be provided with the following :-

a) Arrangements to maintain the cleanliness of the hydraulic fluid taking into consideration the type and design of the hydraulic system;

b) A fixed storage tank having sufficient capacity to recharge at least one power actuating system including the reservoir, where the main steering gear is required to be power operated. The storage tank is to be permanently connected by piping in such a manner that the hydraulic systems can be readily recharged from a position within the steering gear compartment and provided with a contents gauge.

3.3 Valve and relief valve arrangement

3.3.1 For all vessels with non-duplicated actuators, isolating valves are to be fitted at the connection of pipes to the actuators, and are to be directly fitted to the actuator. Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

3.3.2 Relief valves are to be fitted to any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source or from external forces. The setting of the relief valves is not to exceed the design pressure. The valves are to be of adequate size and so arranged as to avoid an undue rise in pressure above the design pressure.

3.3.3 Relief valves, for protecting any part of the hydraulic system which can be isolated, required by 3.3.2 are to comply with the following:

a) The setting pressure is not to be less than 1.25 times the maximum working pressure.

b) The minimum discharge capacity of the relief valve(s) is not to be less than 110 per cent of the total capacity of the pumps which can deliver through it (them). Under such conditions the rise in pressure is not to exceed 10 per cent of the setting pressure. In this regard, due consideration is to be given to extreme foreseen ambient conditions in respect of oil viscosity.

3.4 Flexible hoses

3.4.1 Hose assemblies approved by IRS may be installed between two points where flexibility is required but are not subjected to torsional deflection (twisting) under normal operating conditions. In general, the hose should be limited to the length necessary to provide for flexibility and for proper operation of machinery. (See also Ch.2).

3.4.2 Hoses should be high pressure hydraulic hoses according to recognized standards and suitable for the fluids, pressures, temperatures and ambient conditions in question.

3.4.3 Burst pressure of hoses is not to be less than four times the design pressure.

Section 4

Steering Control Systems

4.1 General

4.1.1 Steering gear control is to be provided:

a) For the main steering gear, both on the navigating bridge and in the steering gear compartment;

b) Where the main steering gear is arranged according to 2.1.4, by two independent control systems, both operable from the navigating bridge. This does not require duplication of the steering wheel or steering lever. Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted, except in a tanker, chemical tanker or gas carrier of 10,000 tons gross and upwards;

c) For the auxiliary steering gear, in the steering gear compartment and, if power operated, it is to be also operable from the navigating bridge and is to be independent of the control system for the main steering gear;

d) Where the steering gear is so arranged that more than one control system can be simultaneously operated, the risk of hydraulic locking caused by a single failure is to be considered.

4.1.2 Any main and auxiliary steering gear control system operable from the navigating bridge is to comply with the following:

a) Means are to be provided in the steering gear compartment for disconnecting any control system operable from the navigating bridge from the steering gear it serves;

b) The system is to be capable of being brought into operation from a position on the navigating bridge.

4.1.3 The angular position of the rudder is to :

a) If the main steering gear is power operated, be indicated on the navigating bridge. The rudder angle indication is to be independent of the steering gear control system.

b) Be recognizable in the steering gear compartment.

4.1.4 Appropriate operating instructions with a block diagram showing the change-over procedures for steering gear control systems and steering gear actuating systems are to be permanently displayed in the wheelhouse and in the steering gear compartment.

4.1.5 Where the system failure alarms for hydraulic lock (See Ch.7) are provided, appropriate instructions are to be placed on the navigating bridge to shut down the system at fault.

IR4.2 Mechanical, hydraulic and electrical independency and failure detection and response of steering control systems

IR4.2.1 Two independent steering gear control systems are to be provided and so arranged that a mechanical, hydraulic or electrical failure in one of them will not render the other one inoperative.

IR4.2.2 The term “steering gear control system” as defined in 1.2.1 is to be understood as “steering control system” covering “the equipment required to control the steering gear power actuating system”.

IR4.2.3 Separation of control systems and components

IR4.2.3.1 General

Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles are to be separated as far as practicable. Where physical separation is not practicable, separation may be achieved by means of a fire retardant plate.

IR4.2.3.2 Steering wheel or steering lever

All electric components of the steering gear control systems are to be duplicated. This does not require duplication of the steering wheel or steering lever.

IR4.2.3.3 Steering mode selector switch

If a joint steering mode selector switch (uniaxial switch) is employed for both steering gear control systems, the connections for the circuits of the control systems are to be divided accordingly and separated from each other by an isolating plate or by air gap.

IR4.2.3.4 Follow-up amplifier

In the case of double follow-up control, the amplifiers are to be designed and fed so as to be electrically and mechanically separated. In the case of non follow-up control and follow-up control, it is to be ensured that the follow-up amplifiers are protected selectively

IR4.2.3.5 Additional control systems

Control circuits for additional control systems, e.g. steering lever or autopilot are to be designed for all pole disconnection.

IR4.2.3.6 Feed-back units and limit switches

The feed-back units and limit switches, if any, for the steering gear control systems are to be separated electrically and mechanically connected to the rudder stock or actuator separately.

IR4.2.3.7 Hydraulic control components

Hydraulic system components in the power actuating or hydraulic servo systems controlling the power systems of the steering gear (e.g. solenoid valves, magnetic valves) are to be considered as part of the steering gear control system and are to be duplicated and separated.

Hydraulic system components in the steering gear control system that are part of a power unit may be regarded as being duplicated and separated when there are two or more separate power units provided and the piping to each power unit can be isolated.

IR4.2.4 Failure detection and response of control systems

IR4.2.4.1 Failure detection

IR4.2.4.1.1 The most probable failures that may cause reduced or erroneous system performance are to be detected and are to consider at least the following:

i) Power supply failure

ii) Loop failures in closed loop systems, both command and feedback loops (normally short circuit, broken connections and earth faults)

iii) If programmable electronic systems are used:

1. data communication errors
2. computer hardware and software failures

Also refer to Ch.7, 6.4 system category III).

iv) Hydraulic locking considering order given by steering wheel or lever.

All failures detected are to initiate an audible and visual alarm on the navigation bridge. Hydraulic locking is to be always warned individually as required in Ch.7, Table 1.9.1, unless system design makes manual action unnecessary.

Guidance Note:
"Hydraulic locking" includes all situations where two hydraulic systems (usually identical) oppose each other in such a way that it may lead to loss of steering. It can either be caused by pressure in the two hydraulic systems working against each other or by hydraulic "by-pass" meaning that the systems puncture each other and cause pressure drop on both sides or make it impossible to build up pressure.

IR4.2.4.1.2 Alternatively to IR4.2.4.1.1 ii) and iii) depending on the rudder characteristic, critical deviations between rudder order and response are to be indicated visually and audibly as steering failure alarm on the navigating bridge.

The following parameters are to be monitored:

Direction	:	Actual rudder position follows the set value
Delay	:	Rudder's actual position reaches set position within acceptable time limits
Accuracy	:	The end actual position is to correspond to the set value within the design offset tolerances

IR4.2.4.1.3 System response upon failure

The most probable failures, e.g. loss of power or loop failure is to result in the least critical of any new possible conditions.

Section 5

Electric Power Circuits, Electric Control Circuits, Monitoring and Alarms

5.1 Electric power circuits

5.1.1 Short circuit protection, an overload alarm and in the case of polyphase circuits, an alarm to indicate single phasing is to be provided for each main and auxiliary motor circuit. Protective devices are to operate at not less than twice the full load current of the motor or circuit protected and are to allow excess current to pass during the normal accelerating period of the motors.

5.1.2 Circuits obtaining their power supply via an electronic converter, e.g. for speed control and which are limited to full load current for continuous rating are exempt from the requirement to provide protection against excess current of magnitude as given in 5.1.1. The overload alarm is to be set to a value for which the electronic converter is designed considering the most severe condition of operation.

5.1.3 Indicators for running indication of each main and auxiliary motor are to be installed on the navigating bridge and at a suitable main machinery control position.

5.1.4 Each electric or electrohydraulic steering gear comprising one or more power units is to be served by at least two exclusive circuits fed directly from the main switchboard; however one of the circuits may be supplied through the emergency switchboard. An auxiliary electric or electrohydraulic steering gear may be connected to one of the circuits supplying the main steering gear. The circuits supplying an electric or electrohydraulic steering gear are to have adequate rating for supplying all motors which can be simultaneously connected to them and may be required to operate simultaneously.

5.1.5 The circuits, required by 5.1.4, are to be separated throughout their length as widely as is practicable.

5.1.6 In ships of less than 1600 tons gross, if an auxiliary steering gear is not electrically powered or is powered by an electric motor primarily intended for other services, the main steering gear may be fed by one circuit from the main switchboard. Consideration would be given to other protective arrangements than described in 5.1.1, for such a motor primarily intended for other services.

5.2 Electric control circuits

5.2.1 Electric control systems are to be independent and separated as far as is practicable throughout their length.

5.2.2 Each main and auxiliary electric control system which is operable from the navigating bridge is to comply with the following:-

a) It is to be served with electric power by a separate circuit supplied from the associated steering gear power circuit, from a point within the steering gear compartment, or directly from the same section of the switchboard busbars, main or emergency, to which the associated steering gear power circuit is connected.

b) Each separate circuit is to be provided with short circuit protection only.

5.3 Monitoring and alarms

5.3.1 All alarms associated with steering gear faults are to be indicated on the navigating bridge and in accordance with the alarm system specified in Ch.7, Table 1.9.1. The alarms are to be both audible and visual.

Section 6

Emergency Power

6.1 General

6.1.1 Where the rudder stock is required to be over 230 [mm] diameter in way of the tiller (See 2.1.1), excluding strengthening for navigation in ice, an alternative power supply, sufficient at least to supply the steering gear power unit which complies with the requirements of 2.1.3 and also its associated control system and the rudder angle indicator, is to be provided automatically, within 45 seconds, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power is to be used only for this purpose.

IR 6.1.1 In the case of non-traditional steering arrangements such as azimuthing propellers, waterjets, etc where the propulsion power exceeds 2,500kW per thruster unit, an alternative power supply, sufficient at least to supply the steering arrangements which complies with the requirements of clause 2.2.3.b and also its associated control system and the steering system response indicator, are to be provided automatically, within 45s, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power is to be used only for this purpose.
The above requirement is relevant for the steering systems having a certain proven steering capability attained due to vessel speed regardless of availability of propulsion power.

6.1.2 In every ship of 10,000 tons gross and upwards, the alternative power supply is to have a capacity for at least 30 minutes of continuous operation and in any other ship for at least 10 minutes.

6.1.3 Where the alternative power source is a generator, or an engine driven pump, starting arrangements are to comply with the requirements relating to the starting arrangements of the emergency generators.

Section 7

Testing and Trials

7.1 Testing

7.1.1 The requirements of the Rules relating to the testing of Class 1 pressure vessels, piping, and related fittings including hydraulic testing apply.

7.1.2 After installation on board the vessel the steering gear is to be subjected to the required hydrostatic and running tests.

7.1.3 Each type of power unit pump is to be subjected to a type test. The type test is to be for a duration of not less than 100 hours, the test arrangements are to be such that the pump may run in idling conditions, and at maximum delivery capacity at maximum working pressure. During the test, idling periods are to be alternated with periods at maximum delivery capacity at maximum working pressure. The passage from one condition to another should occur at least as quickly as on board. During the whole test no abnormal heating, excessive vibration or other irregularities are permitted. After the test, the pump is to be opened out and inspected. Type tests may be waived for a power unit which has been proven to be reliable in marine service.

7.2 Trials

7.2.1 The steering gear is to be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of the Rules have been met. The trial is to include the operation of the following :-

i) The steering gear; including demonstration of the performances required by 2.1.2 (b) and 2.1.3 (b). In order to demonstrate this ability, the trials may be conducted in accordance with Section 6.1.5.1 of ISO 19019:2005 “Sea-going vessels and marine technology – Instructions for planning, carrying out and reporting sea trials”.

The above is to be to the satisfaction of IRS.

ii) The steering gear power units, including transfer between steering gear power units;

iii) The isolation of one power actuating system, checking the time for regaining steering capability;

iv) The hydraulic fluid recharging system;

v) The emergency power supply required by 6.1.1;

vi) The steering gear controls, including transfer of control and local control;

vii) The means of communication between the steering gear compartment and wheelhouse, also the engine room, if applicable;

viii) The alarm and indicators;

ix) Where the steering gear is designed to avoid hydraulic locking, this feature is to be demonstrated.

Test of items (iv), (vii), (viii) and (ix) may be effected at the dockside.

Section 8

Additional Requirements

8.1 For tankers, chemical tankers or gas carriers of 10,000 tons gross and upwards and every ship of 70,000 tons gross and upwards

8.1.1 The main steering gear is to comprise two or more identical power units complying with the provisions of 2.1.4.

8.2 For tankers, chemical tankers or gas carriers of 10,000 tons gross and upwards

8.2.1 Subject to 8.3, the following are to be complied with :

a) The main steering gear is to be so arranged that in the event of loss of steering capability due to a single failure in any part of one of the power actuating systems of the main steering gear, excluding the tiller, quadrant or components serving the same purpose, or seizure of rudder actuators, steering capability is to be regained in not more than 45 seconds after the loss of one power actuating system.

b) The main steering gear is to comprise either;

   i) two independent and separate power actuating systems, each capable of meeting the requirements of 2.1.2 (b); or

   ii) at least two identical power actuating systems which, acting simultaneously in normal operation are capable of meeting the requirements of 2.1.2(b). Where necessary to comply with these requirements, inter- connection of hydraulic power actuating systems is to be provided. Loss of hydraulic fluid from one system is to be capable of being detected and the defective system automatically isolated so that the other actuating system or systems remain fully operational.

c) Steering gears other than of the hydraulic type are to achieve equivalent standards.

8.3 For tankers, chemical tankers or gas carriers of 10,000 tons gross and upwards but of less than 100,000 tonnes deadweight

8.3.1 Solutions other than those set out in 8.2.1 which need not apply the single failure criterion to the rudder actuator or actuators, may be permitted provided that an equivalent safety standard is achieved and that:

a) Following loss of steering capability due to a single failure of any part of the piping system or in one of the power units, steering capability is regained within 45 seconds; and

b) Where the steering gear includes only a single rudder actuator special consideration is given to stress analysis for the design including fatigue analysis and fracture mechanics analysis, as appropriate, the material used, the installation of sealing arrangements and the testing and inspection and provision of effective maintenance. In consideration of the foregoing, regard will be given to the "GUIDELINES" in Sec.9.

8.3.2 Manufacturers of steering gear who intend their product to, comply with the requirements of the Sec.9 are to submit full details when plans are forwarded for approval.

Section 9

Guidelines for the Acceptance of Non-duplicated Rudder Actuators for Tanker, Chemical Tankers or Gas Carriers of 10,000 tons gross and upwards but of less than 100,000 tonnes Deadweight

9.1 Materials

9.1.1 Parts subject to internal hydraulic pressure or transmitting mechanical forces to the rudder-stock are to be made of duly tested ductile materials complying with recognized standards. Materials for pressure retaining components are to be in accordance with recognized pressure vessel standards. These materials are not to have an elongation less than 12 per cent nor a tensile strength in excess of 650 [N/mm^2].

9.2 Design

9.2.1 **Design pressure** The design pressure should be assumed to be at least equal to the greater of the following :-

a) 1.25 times the maximum working pressure to be expected under the operating conditions required in 2.1.2(b).

b) The relief valves(s) setting.

9.2.2 **Analysis** In order to analyse the design the following are required :

a) The manufacturers of rudder actuators should submit detailed calculations showing the suitability of the design for the intended service.

b) A detailed stress analysis of the pressure retaining parts of the actuator should be carried out to determine the stresses at the design pressure.

c) Where considered necessary because of the design complexity or manufacturing procedures, a fatigue analysis and fracture mechanics analysis may be required. In connection with these analyses, all foreseen dynamic loads should be taken into account. Experimental stress analysis may be required in addition to, or in lieu of, theoretical calculations depending upon the complexity of the design.

9.2.3 **Dynamic loads for fatigue and fracture mechanics analysis** The assumptions for dynamic loading for fatigue and fracture mechanics analysis where required by 3.1.5, 8.3 and 9.2.2 are to be submitted for appraisal. Both the cases of high cycle and cumulative fatigue are to be considered.

9.2.4 **Allowable stresses** For the purpose of determining the general scantlings of parts of rudder actuators subject to internal hydraulic pressure the allowable stresses should not exceed:

$$\sigma_m \leq f$$

$$\sigma_p \leq 1.5\ f$$

$$\sigma_b \leq 1.5\ f$$

$$\sigma_p + \sigma_b \leq 1.5\ f$$

$$\sigma_m + \sigma_b \leq 1.5\ f$$

where,

σ_m = equivalent primary general membrane stress

σ_p = equivalent primary local membrane stress

σ_b = equivalent primary bending stress

f = the lesser of $\dfrac{\sigma B}{A}$ or $\dfrac{\sigma Y}{B}$

σB = specified minimum tensile strength of material at ambient temperature

σY = specified minimum yield stress or 0.2 percent proof stress of material at ambient temperature

A and B are as follows :

	Wrought Steel	Cast Steel	Nodular Cast Iron
A	4	4.6	5.8
B	2	2.3	3.5

9.2.5 **Burst test** Pressure retaining parts not requiring fatigue analysis and fracture mechanics analysis may be accepted on the basis of a certified burst test and the detailed stress analysis required by 9.2.2 need not be provided. The minimum bursting pressure should be calculated as follows :-

$$P_b = P\,A\,\frac{\sigma B_a}{\sigma B}$$

where,

P_b = minimum bursting pressure

P = design pressure as defined in 9.2.1

A = as defined in 9.2.4

σB_a = actual tensile strength

σB = tensile strength as defined in 9.2.4.

9.3 Construction details

9.3.1 General The construction should be such as to minimize local concentration of stress.

9.3.2 Welds

a) The welding details and welding procedures should be approved.

b) All welded joints within the pressure boundary of a rudder actuator or connection parts transmitting mechanical loads should be full penetration type or of equivalent strength.

9.3.3 Oil seals Oil seals forming part of the external boundary are to comply with 3.2.3 and 3.2.4.

9.3.4 Isolating valves Isolating valves are to be fitted at the connection of the pipes to the actuator, and should be directly mounted on the actuator.

9.3.5 Relief valves Relief valves for protecting the rudder actuator against over-pressure as required in 3.3.2 are to comply with the following:

a) The setting pressure is not to be less than 1.25 times the maximum working pressure expected under operating conditions required by 2.1.2(b).

b) The minimum discharge capacity of the relief valve(s) is to be not less than 110 per cent of the total capacity of all pumps which provide power for the actuator. Under such conditions the rise in pressure should not exceed 10 per cent of the setting pressure. In this regard due consideration should be given to extreme foreseen ambient conditions in respect of oil viscosity.

9.4 Non-destructive testing

9.4.1 The rudder actuator should be subjected to suitable and complete non-destructive testing to detect both surface flaws and volumetric flaws. The procedure and acceptance criteria for non-destructive testing should be in accordance with requirements of recognized standards. If found necessary, fracture mechanics analysis may be used for determining maximum allowable flaw size.

9.5 Testing

9.5.1 Tests, including hydrostatic test, of all pressure parts at 1.5 times the design pressure should be carried out.

9.5.2 When installed on board the ship, the rudder actuator should be subjected to a hydrostatic test and a running test.

End of Chapter

Chapter 7

Control Engineering

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter are in general to be complied with for all machinery plants where instrumentation is required according to other Chapters of the Rules. In addition, the requirements apply to the following, when installed :-

a) remote control systems for propulsion machinery, controllable pitch propeller, and steering gear;

b) safety systems for propulsion plants and electric power generating plants;

c) instrumentation equipment of boiler plants.

d) Safety systems for emergency diesel engines.

1.1.2 For vessels intended to operate with unattended machinery spaces, refer to Pt.5.

1.1.3 Alarm systems are to satisfy the environmental requirements of IRS Classification Notes "Type Approval of Electrical Equipment used for Control, Protection, Safety and Internal Communication in Marine Environment".

1.2 Remote control systems capability

1.2.1 When it is desired to fit a centralized control system having one or more control locations and embodying various degrees of automatic and remote control of the propulsion plant or associated ship's service systems, the control and monitoring systems are to be designed, assembled and installed in accordance with the requirements given in Section 5, to assure operation as effective as could be obtained with the same systems arranged for manual control and monitoring by watchkeeping personnel.

1.3 Plans and particulars

1.3.1 Plans and specifications for the control systems, are to be submitted, in triplicate, for approval and are to at least include the following information:

a) machinery arrangement plans showing locations control in relation to controlled units;

b) arrangements and details of control consoles including front views, installation arrangements together with schematic diagrams for all power, control and monitoring systems including their functions;

c) kind and size of all electrical cables and wiring associated with the control systems including voltage rating, service voltage and currents together with overload and short circuit protection;

d) functional block diagrams of all control and monitoring systems;

e) schematic plans of hydraulic and pneumatic control systems together with all inter-connections, piping sizes and materials including working pressures, relief valve settings, reducing valves, filters, compressors and their type and manufacturers;

f) description of all alarm and emergency tripping arrangements, functional sketches or description of all special valves, actuators, sensors and relays;

g) schematic plans and supporting data of fire-protection and extinguishing systems, including fire-detection and alarm systems, bilge high level alarms;

h) control system fault analysis, test program for testing controls, monitoring and alarm systems.

1.4 Operational guidance manual

1.4.1 An operational guidance manual is to be provided on board the vessel for reference and is to contain the necessary system technical information and give operating instructions for normal and emergency operations.

1.5 Location of controls

1.5.1 Ship motion and anticipated structural vibrations are to be considered when selecting the locations of main and associated secondary control locations.

1.5.2 The control locations are to be well ventilated and air conditioning is to be provided for the control consoles when required by the operational characteristics of the components within the consoles. There is to be an alarm for failure of the console integral air conditioning.

1.5.3 Enclosed main control location located within the machinery spaces are to have two means of access located as remote from each other as practicable.

1.5.4 The leading of pipes in the vicinity of control console is to be avoided as far as possible. When such leads are necessary, care is to be taken to fit no flanges or joints over or near the console unless provision is made to prevent any leakage from injuring the equipment.

1.5.5 Glass in a control room located within or adjacent to the machinery space is to be of the shatter-resistant type.

1.5.6 When the main control for the propulsion plant is to be situated in a location remote from the propulsion machinery space, details of special arrangements are to be submitted to show that the operation of the propulsion plant would be as effective as with the main control located within or adjacent to the machinery space.

1.6 Main control location

1.6.1 Controls

1.6.1.1 The main control location is to provide control of the propulsion plant and associated ship's service system including starting, stopping, and for change over of vital pumps and motors, and is to provide effective means for monitoring temperatures, pressures, the electrical system, fluid and gas flows, liquid levels and other variables which are essential for the propulsion plant operation.

1.6.1.2 Effective means are to be provided for monitoring and controlling direction of rotation or propeller pitch and speed of propeller for the safe operation of the plant from standby condition at departure through normal operation to "finished with engines" at the end of the voyage.

1.6.1.3 The main control location is to be fitted with alarms and emergency trips as required together with indicators and is to have means for the assessment of the operational status of all machinery and systems vital to the propulsion of the vessel. Control functions from the console may be designed for either 'remote manual' or 'automatic control'.

1.6.2 Independent manual control

1.6.2.1 Means are to be provided for independent manual control, at or near the machinery concerned, in the event of failure of a particular control in the centralized control system. Necessary instrumentation is to be provided so that satisfactory operation of the machinery under independent manual control can be exercised for lengthy periods. Independent manual control of propulsion machinery is to be demonstrated during the tests/trials to the satisfaction of the Surveyors.

This is to include demonstration of independent manual control through the full maneuvering range and transfer from automatic control.

1.6.3 Order of control-location command

1.6.3.1 When the propulsion machinery is arranged to be controlled from two or more locations, the main control location is to have means for transferring control from a secondary location to the main location at all times and blocking any unauthorized control from any secondary location. Consideration will be given to special cases where it may be necessary for a secondary control location to have command over control transfers between control locations.

1.6.4 Control transfer

1.6.4.1 Transfer of control from one location to another, except as required by 1.6.3.1, is to be possible only with acknowledgement by the receiving locations. The main control location and the secondary control location are to have an indicator showing which location is in control.

1.7 Secondary control locations

1.7.1 In general, secondary control locations for the control of propulsion machinery from the bridge or other locations on board are to be kept as simple as possible and provided with only those indicators and controls necessary for the effective control of speed and direction of the propulsion engines, and of the controllable-pitch propeller where fitted, for normal operation.

1.7.2 Precautions are to be taken to ensure that the engine is not normally operated in a barred speed range.

1.7.3 If the control system automatically shuts down the main propulsion engine for any reason, this is to be alarmed at the main control location and each secondary control location. Restoration of normal operating conditions is to be possible only after manual reset. Automatic restarting is not to be possible.

1.8 Control console construction

1.8.1 Control consoles are to be preferably self-supported with the sides and backs suitably protected. Where necessary, protection is to be provided for consoles which might be subject to damage by leaks or falling objects.

1.9 Instrumentation

1.9.1 Main control location

1.9.1.1 Instrumentation and alarms at the main control location are to provide all information necessary for monitoring the operation of the propulsion, electrical and emergency systems, generally in accordance with Table 1.9.1.

1.9.2 Secondary control location

1.9.2.1 Instrumentation and alarms for the bridge control locations and other secondary control locations are to be generally in accordance with Table 1.9.2.

1.10 Displays, indications and alarms

1.10.1 The alarms and displays required by Table 1.9.1 and Table 1.9.2 for essential services are to be readily distinguishable from other alarms (e.g. fire alarm) and are to be grouped functionally in so far as practicable. Alarms are to have individual visual presentation with preferably a common audible signal.

1.10.2 In general, alarms and displays not required by Table 1.9.1 and Table 1.9.2 or not concerned with the management of the propulsion machinery (non- essential alarms) are to be grouped separately from the essential alarms. Audible signals for non-essential alarms, if provided, are to be of a character distinct from that for essential alarms.

1.10.3 The number of colours used to indicate status of plant operation is to be kept to a minimum. A uniform code is to be used so that like colours indicate like functions or status of operation in the controlled plant or system.

1.10.4 Alarm systems are to be designed so that they cannot remain deactivated when the monitoring system has returned to the normal running condition. Alarm systems are to provide both audible and visual alarm upon each fault condition. Alarms, due to fault condition in machinery, are to remain active until acknowledged and if arrangements are made to mute audible alarms they are not to extinguish visual alarms. Acknowledgement of visual alarms is to be clearly indicated. Alarms are to be of the self-monitoring type so that a circuit failure will cause an alarm condition and are to have provisions for testing all audible and visual alarms and indicating lamps.

1.10.5 Machinery, safety and control system faults are to be indicated at the relevant control locations to advise duty personnel of a fault condition. The presence of unrectified faults is to be clearly indicated at all times.

1.10.6 Where the alarms are displayed as group alarms provision is to be made to identify individual alarms at the main control location (if fitted) or alternatively at subsidiary control locations.

1.10.7 Acknowledgement of alarms at positions outside a machinery space is not to silence the audible alarm or extinguish the visual alarm in that machinery space.

1.10.8 If an alarm has been acknowledged and a second fault occurs prior to the first being rectified, audible and visual alarms are again to operate. Where alarms are displayed at a local panel adjacent to the machinery and with arrangements to provide a group or common fault alarm at the main control room alarm display then the occurrence of a second fault prior to the first alarm being rectified need only be displayed at the local panel, however, the group alarm is to be re-initiated. Unacknowledged alarms on monitors are to be distinguished by either flashing text or a flashing marker adjacent to the text. A change of colour will not in itself be sufficient to distinguish between acknowledged and unacknowledged alarms.

1.10.9 For the detection of transient faults which are subsequently self-correcting, alarms are required to lock in until accepted.

1.10.10 The alarm system is to be arranged with automatic changeover to a standby power supply in the event of a failure of the normal power supply. Where an alarm system could be adversely affected by an interruption in power supply, changeover to the standby power supply is to be achieved without a break.

1.10.11 Failure of any power supply to the alarm system is to operate an audible and visual alarm at the main control location.

1.10.12 The alarm system is to be capable of being tested during normal machinery operation.

1.10.13 The alarm system is to be designed as far as practicable to function independently of control and safety systems such that a failure or malfunction in these systems will not prevent the alarm system from operating.

1.10.14 Disconnection or manual overriding of any part of the alarm system should be clearly indicated.

1.10.15 When alarm systems are provided with means to adjust their set point, the arrangements are to be such that the final settings can be readily identified.

1.10.16 Where monitors are provided at the location in control and if fitted, in the duty engineer’s accommodation, they are to provide immediate display of new alarm information regardless of the information display page currently selected. This may be achieved by provision of a dedicated alarm monitor, a dedicated area of screen for alarms or other suitable means.

1.10.17 Alarms are to be displayed in the order in which they occur. Alarms requiring shutdown or slowdown action are to be given visual prominence.

1.11 Safety systems

1.11.1 Where safety systems are provided, the requirements of Pt.5, Ch.22, 2.5.2 to 2.5.8 are to be complied with.

1.11.2 Where arrangements are provided for over-riding a safety system, they are to be such that in-advertent operation is prevented. Visual indication is to be given at the relevant control location(s) when a safety over-ride is operated. The consequences of over-riding a safety system are to be established and documented.

Table 1.9.1 : Displays, indications and alarms for main control location				
	System	**Remote Display**	**Alarm activation**	**Remarks**
Main boilers				
1	Main steam superheater outlet	Temperature Pressure	High	-
2	Fuel oil to burners	Pressure Viscosity (temperature)	Low High (low)	-
3	Master fuel oil cut-off valve	-	Closed	-
4	Atomizing medium	Pressure	Outside limits	-
5	Forced draft	Pressure (water column)	Failure	-
6	Water level	Level	High, low Low-low	-
7	Feed pump discharge	Pressure		-
8	Feed water salinity	Salinity	-	-
Main turbine				
1	Steam, ahead chest	Pressure	-	-
2	Steam, astern chest	Pressure	-	-
3	Steam, gland steam	Pressure	-	-
4	L.O. to turbines and reduction gears	Temperature Pressure	High Low	-
5	L.O. sump level	-	Low	-
6	L.O. gravity tank	Level	Low	-
7	Bearings, turbine, thrust and reduction gear (individual)	Temperature	High	-
8	Main condensate pump	Running	Failure	-
9	Main condenser	Vacuum	Low	-
10	Main circulator	Running	Failure	-
11	Condensate level	-	High	-
12	Deaerator feed tank	Level	Low	-
13	Astern guardian valve	Position	Failure to open	-
14	Vibration	-	Excessive	-
15	Rotor axial displacement	-	Excessive	-
16	Shaft roll over	-	Stopped	-
17	Scoop valve	Position	-	-
18	Main circulator sea suction valve	Position	-	-
Turbogenerator				
1	L.O. to turbine and reduction gear	Pressure Temperature	Low High	-
2	Bearings	Temperature	High	-
3	Aux. Condenser	Vacuum	Low	-
4	Aux. Condensate pump	Running	-	-
5	Aux. Circulating pump	running	-	-

Table 1.9.1 : (Contd.)				
	System	**Remote Display**	**Alarm activation**	**Remarks**
Main diesel engines				
1	L.O. to engine	Pressure Temperature	Low High	See Note 1
2	Differential pressure across L.O. discharge filter	Pressure	High	-
3	L.O. to reduction gear	Pressure	Low	-
4	L.O. at reduction gear	Temperature	High	-
5	Oil mist concentration in crankcase or temperature of bearings or equivalent devices	-	High	See Note 16
6	L.O. drain tank level	-	Low-high	See Note 2
7	Cylinder lubrication	-	Failure	See Note 1
8	Cooling water to cylinders	Pressure or flow	Low	See Note 9
9	Cylinder cooling water outlet	Temperature	High	See Note 3
10	Level of cylinder cooling water in expansion tank	-	Low	-
11	Piston coolant	Pressure	Low	See Note 4
12	Flow of piston coolant through each piston and temperature in manifold (or temperature of coolant at each piston outlet)	Flow, temperature (or temperature)	Low-high (high)	See Note 4
13	Level of piston coolant in expansion tank	-	Low	See Note 4
14	Fuel valve coolant	Pressure Temperature	Low High	-
15	Level of fuel valve coolant in expansion tank	-	Low	-
16	Sea water coolant	Pressure	Low	See Note 9
17	F.O. to injection pumps	Pressure	Low	-
18	F.O. to engine	Temperature or viscosity	Low-high (Low-high)	See Note 7
19	Level of F.O. in daily service tank	-	Low-high	See Note 5
20	Charging air	Temperature	Low-high	See Note 6
21	Deviation of each cylinder from average and exhaust gas temperature of each engine	Temperature	High	See Note 8
22	Fire in scavenging belt, for two stoke engines	-	Activated	See Note 10
23	Starting air	Pressure	Low	-
24	Overspeed	-	Activated	-

Table 1.9.1 : (Contd.)

	System	Remote Display	Alarm activation	Remarks
Diesel generators				
1	F.O. to engines	Pressure	Failure	-
2	L.O. to engines	Pressure Temperature	Low High	-
3	Starting air	Pressure	Low	-
4	Exhaust gas	Temperature	-	-
5	Cooling medium, outlet	Temperature Pressure	High Low	See Note 9
6	Level in cooling water expansion tank, if not connected to main system	-	Low	-
7	overspeed	-	Activated	-
Steering gear				
1	Rudder position	Indication	-	See Note 12
2	Steering gear power units	-	Failure	-
3	Steering gear motors	Running and stopped indication	Overload and single phase	See Note 13
4	Control system power	-	Failure	-
5	Steering gear hydraulic oil tank level	-	Low	See Note 14
6	Auto pilot indication	Running indication	Failure	-
7	Hydraulic lock	-	Fault	See Note 15
Addition services as applicable				
1	Control electric power	available	Failure	-
2	Control air supply	Pressure	Low	-
3	Hydraulic control system	Pressure	Low	-
4	Control location in operation	In command indication	-	-
5	Propeller pitch indicator	Pitch	-	-
6	Propeller speed, direction	RPM, direction	-	-
7	Stern tube L.O. tank level	-	Low	-
8	F.O. service or settling tank	-	Low, high	-
9	F.O. settling tank temperature	-	High	-
10	Generators, ship service	Volts amperes Frequency	Off limits High off limits	-
11	Fuel oil service pump	Running	-	-
12	Console air conditioning	-	Failure	-
13	Automatic shut down	-	Shut-down	-
14	Turning gear	Engaged	-	-
15	Fire main	Pressure	-	-
16	Bilge pump	Running	-	-
17	Bilge level	-	High	-
18	Clutch air or oil pressure	-	Low	-

Table 1.9.1 : (Contd.)

Notes:

1 Individual alarms are required where separate lubricating oil systems (e.g. for camshaft, rocker arms, turbocharger, etc.) are installed. For turbochargers with an integrated self-contained oil lubrication system such alarm is not required.

2 Where separate lubricating oil systems are installed, individual level alarms are required for the tanks.

3 Where one common cooling space without individual stop valves is employed for all cylinder jackets, one temperature alarm for the common cooling water outlet will be approved.

4 Only applicable for cross-head type engines.

5 High-level alarm is required only if suitable overflow arrangements are not provided.

6 Both the displays and alarms are not required if automatic temperature control is not necessary. Low temperature alarm may be replaced by an alarm for water detection in the charging air duct.

7 Not required for distillate fuels.

8 Alarm for slow speed engines (under 300 RPM) and medium speed engines above 4000 bhp.

9 Not required for attached cooling pumps.

10 Not required for engines with bore 300 [mm], or under.

11 Alarms required for steering gear need to be fitted only on the bridge.

12 The rudder angle indication is to be on the navigation bridge and independent of the steering gear control system.

13 Steering gear motors running indicators are to be fitted both on the bridge and main control location.

14 Each tank is to be monitored.

15 Where more than one system (either power or control) can be operated simultaneously each system is to be monitored and the system at fault is to be identified.

16 If engine power is $\geq$ 2250 [kW] or cylinder bore > 300 [mm], following is to be provided:

- Oil mist detection arrangements or engine bearing temperature monitors or equivalent devices.
- Slow down with alarm for low speed diesel engines
- Shut down with alarm for medium and high speed engines.
- IRS may permit overriding of auto shut off or slow down arrangements, provided consequences of overriding auto shut off or slow down are established and documented.
- For the purpose of this requirement :-
    - o Low speed engines means diesel engines having a rated speed of less than 300 rpm
    - o Medium speed engines means diesel engines having a rated speed of 300 rpm and above, but less than 1400 rpm.
    - o High Speed engines means diesel engines having a rated speed of 1400 rpm and above

Table 1.9.2 : Displays, indications and alarms for secondary control location

	System	Display	Alarm	Remarks
1	Control location	In command	-	-
2	Propeller speed and direction	Ahead, astern, RPM	-	-
3	Propeller pitch	Pitch	-	-
4	Starting air pressure	-	Low	-
5	Propulsion unit	-	Abnormal	-
6	Remote control power	-	Failure	-
7	Shaft roll over	-	Stopped	-
8	Bilge level	-	High	-

Section 2

Control - System Characteristics

2.1 Power supply

2.1.1 The control systems are to be served by two feeders from the main switchboard. One of the feeders may be from the emergency switchboard, if provided. Transfer may be by manual or automatic switch installed in or adjacent to the control console. The feeder from the transfer switch to the control console may be through a single cable. These feeders are not to supply power for any other machinery.

2.1.2 The feeders supplying power to the control console are to be provided with short- circuit protection at the main switchboard and emergency switchboards, if provided. Where circuits within the control consoles are protected by fuses or circuit breakers, the control-system protection is to be subdivided and arranged so that failure of one set of fuses or circuit breakers will not cause maloperation or failure of another circuit or system and it is to be possible to isolate the defective system.

2.1.3 The power for monitoring, alarms and emergency action is to be supplied automatically from an emergency source upon failure of ship's service power supply. An audio / visual alarm is to be provided at the main control location to indicate failure of power supply.

2.1.4 Cables and console wiring for control and monitoring are to be of the flame-retarding type and are to be stranded except that solid conductors may be used in low energy circuits, where they are properly supported and not subject to undue vibration or movements.

2.1.5 Conductors for monitoring circuits which carry low-level or information-level signals are to be installed in such a manner or provided with shields so as to minimize the introduction of spurious signals from outside sources. Wiring within consoles is to be arranged to provide maximum accessibility and protection from steam, water or oil piping.

2.2 Electrical and electronic devices

2.2.1 All electrical and electronic devices are to be suitable for use in marine atmosphere, resistant to corrosion, not affected by shipboard vibration and motion and are to be capable of performing their intended functions at compartment ambient temperature. Electrical and electronic devices are to be applied on the basis of 50°C ambient when located in machinery spaces or 40°C ambient when located in other spaces, including those cases when the component is located in an airconditioned console.

2.2.2 Semiconductor devices are to be selected on the basis of expected shipboard ambient air-temperature ranges of 0°C-50°C for interior compartments and 0°C-60°C inside of consoles. Silicon and selenium semiconductor devices are to be used in preference to germanium which may be used, where its characteristics are favoured for a circuit provided care is taken to ensure satisfactory operation under shipboard conditions.

2.2.3 Steady-state voltage variations of 10 per cent and frequency variations of ± 5 per cent from the nominal console feeder rating are not to affect the intended functioning of the electrically operated control and monitoring devices. Where close tolerances on voltage and frequency are required, special regulated supplies are to be provided. Voltage transients are not to cause any dangerous malfunctioning or damage to the control and monitoring devices and the control equipment is to be fitted with transient- voltage suppressors.

2.2.4 The design and arrangement of all devices is to provide ready accessibility to parts requiring inspection, adjustment or periodic replacement. Where devices are parts of sub-circuits assembled in physically-identical modular units for easy mounting on and removal from the console, suitable arrangements such as matched plug-in modules with coded plugs are to be provided to facilitate correct replacement of modules in the console.

2.2.5 Built-in circuitry is to be provided for use in the testing of module functions.

2.2.6 Consideration is to be given to minimize, as far as practicable, the probability that failure of any one component or device in the control circuitry will cause unsafe operation of the plant.

2.2.7 Control levers or wheels are to be readily identifiable as to function and position and are to be arranged for a logical sequence of operations. Suitable interlocks are to be provided to prevent incorrect operation.

2.2.8 When logic circuits are used for sequential start-up or for operating individual plant, components, indicators are to be provided at the control console to show the successful completion of the sequence of operations by the logic circuit and start-up and operation of the component. If some particular step is not carried out during the sequence, the sequence is to stop at this point. Manual override is to be fitted in vital functions to permit control in case of failure of a logical circuit.

2.2.9 Electrically-powered actuators for the execution of control commands are to be suitable for shipboard use, and have working and other parts which would not be damaged or rendered ineffective by corrosion. The windings are to be treated to resist oil and water and the enclosures are to be suitable for the location. The ratings of coils is to be based on ambient air temperature of 50°C when located in the machinery spaces and 40°C when located outside such spaces. The power supply for electrical actuators is to be from the same source as the power to the control systems.

2.3 Hydraulic controls

2.3.1 Hydraulic pumps, actuators, motors and accessories are to be suitable for the intended duty, compatible with the working fluid and are to be designed to operate safely at full-power conditions. In general, the hydraulic fluid is to be non-flammable or have a flash point above 157°C.

2.3.2 All control piping is to be readily accessible and supported so as to protect the piping and associated accessories from mechanical damage, vibration and shock. The control piping is to be suitably marked to indicate the character of its service.

2.3.3 The hydraulic pumps are to be fitted in duplicate and have pressure relief protection on the discharge side. The pump suctions are to be from a reservoir of sufficient capacity to contain all the fluid when drained from the system, maintain the fluid level at an effective working height and allow air and foreign matter to separate out. The pump suctions are to be sized and positioned to prevent cavitation or starvation of a pump. A duplex filter which can be cleaned without interrupting the oil supply is to be fitted on the discharge side of the pumps.

2.4 Pneumatic controls

2.4.1 Air compressors, actuators, motors and accessories are to be suitable for the intended duty and have working and other parts which will not be damaged or rendered ineffective by corrosion.

2.4.2 All control piping is to be readily accessible and supported so as to protect the piping and associated accessories from mechanical damage, vibration and shock. The control piping is to be suitably marked to indicate the character of its service.

2.4.3 Compressed air for pneumatic control is to be available from at least two air compressors. The starting air system may be used as a source of control air. The air pressure to the pneumatic control system is to be automatically maintained at the level required for the operation of the installation and low air pressure is to set off an alarm at the main control location. Means are to be provided in the delivery from the compressors to assure clean, dry and oil-free air to the pneumatic controls.

2.5 Ship motion effects

2.5.1 All control, actuating, monitoring and alarm devices are to be able to operate successfully when inclined at an angle of 30° in any direction from the vertical and when subjected to vibratory frequencies of 2 to 80 Hz, in conjunction with peak to peak amplitudes of 2 [mm] for frequencies 2 to 13.2 Hz and an acceleration of 0.7 g for frequencies of 13.2 to 80 Hz. Care is to be taken to ensure that mounting arrangements for the components will not amplify shipboard vibrations.

2.6 Bridge control for main propulsion machinery

2.6.1 Where a bridge control system for main propulsion machinery is to be fitted, the requirements of 2.6.2 to 2.6.8 are to be complied with.

2.6.2 Means are to be provided to ensure satisfactory control of propulsion from the bridge in both the ahead and astern directions.

2.6.3 Instrumentation to indicate the following is to be fitted on the bridge:

a) Propeller speed.
b) Direction of rotation of propeller for a fixed pitch, propeller or pitch position for controllable pitch propeller.
c) Clutch position where applicable.
d) Shaft brake position where applicable.
e) Engine speed.

2.6.4 The propeller speed, direction of rotation and, if applicable, the propeller pitch are to be controlled from the bridge under all normal sea going and manoeuvring conditions.

2.6.5 Remote control of the propulsion machinery is to be from one control location at any one time. See also 1.6.3. Main propulsion control units on the navigating bridge may be interconnected. Means are to be provided at the main machinery control location to ensure smooth transfer of control between the bridge and machinery control locations.

2.6.6 Means of control, independent of the bridge control system, are to be provided on the bridge to enable the propulsion machinery to be stopped in an emergency.

2.6.7 Audible and visual alarms are to operate on the bridge and in the locations required by Pt.5, Ch.22 if any power supply to the bridge control system fails. Where practicable the preset speed and direction of thrust are to be maintained until corrective action is taken.

2.6.8 At least two means of communication are to be provided between the bridge and the main control location in the machinery space. One of these means may be the bridge control system; the other is to be independent of the main electrical power supply. See also Pt.4, Ch.1, Sec.2, Cl. 2.5.

2.7 Valve control system

2.7.1 Where bilge, ballast, oil fuel transfer and sea valves for engine services are operated by remote or automatic control, the requirements of 2.7.2 to 2.7.5 are to be satisfied.

2.7.2 Failure of actuator power is not to permit a valve to move to an unsafe condition.

2.7.3 Positive indication is to be provided at the remote control location for the service to show the actual valve position or alternatively that the valve is fully open or closed.

2.7.4 Equipment located in places which may be flooded is to be capable of operating when submerged.

2.7.5 A secondary means of operating the valves, which may be by local manual control, is to be provided.

2.7.6 For requirements applicable to closing appliances on scuppers and sanitary discharges, see Pt.3, Ch.13.

Section 3

Requirements for various Machinery Installations

3.1 Boilers

3.1.1 General

3.1.1.1 Where a boiler-control system is fitted for the purpose of automatically controlling the combustion, feed water and firing functions, the arrangements are to be capable of automatically and safely satisfying the steam requirements demanded from the boiler under normal evaporation between minimum and maximum firing rates and be able to maintain complete and stable combustion at the minimum rate of firing or during any sudden change in steam demand.

3.1.1.2 To prevent a build-up of excessive boiler steam which might occur when all burners are in service and burners are at the minimum firing rate, one of the following arrangements or equivalent is to be provided:-

a) Burners sequencing, which may require automatic control of one or more, but not necessarily all, burners in the boiler;

b) an automatic steam dump system, unloading to a condenser of adequate size.
For long-term operation at low loads, the excess burner capacity may be secured.

3.1.2 Fuel oil system

3.1.2.1 A master fuel oil cut-off valve is to be provided in the fuel system to each boiler. The valve is to be automatically closed upon flame failure of all burners in the boiler or upon action of the low-water alarm or upon loss of forced draft. The closing of the master fuel oil valve is to be alarmed at the main control location. Before any attempt at restarting after a complete flame out, manual intervention is to be initiated to determine the cause of flame failure and to reset the master fuel-oil valve.

3.1.2.2 The oil burners are to be so arranged that they cannot be withdrawn unless oil supply to the burners is cut off.

3.1.3 Combustion-control safety

3.1.3.1 Each burner is to be fitted with a flame scanner designed to automatically shut off the fuel oil supply to the burner in the event of flame failure. The flame failure shut off is to be capable of shutting off the oil supply to the burner within 6 seconds following flame failure. In the case of the failure of the flame scanner, the fuel to the burner is to be shut off automatically. On flame failure of all burners in boilers fitted with an automatic ignition system, the control system is to go to the automatic boiler purge condition.

3.1.3.2 Where boilers are fitted with an automatic ignition system, a timed boiler purge with all air registers open is required prior to ignition of the initial burner. The boiler purge may be initiated manually or automatically. The purge time is to be based on a minimum of four air changes of the combustion chamber and furnace passes. It is to be proven that the forced draft fan is operating and the air registers and dampers are open before the purge time commences.

3.1.3.3 Means provided to by-pass the flame-scanner control system temporarily during a trial- for ignition period is to be limited to 15 seconds from the time the fuel reaches the burners. Except for this trial- for-ignition period there is to be no means provided to by-pass one or more of the burner flame scanner systems unless the boiler is being manually fired.

3.1.3.4 Where boilers are fitted with an automatic ignition system, and where residual fuel oil is used, means are to be provided for lighting off the burners with igniters lighting properly heated residual fuel oil. Alternatively, the burners may be lighted off with a light oil used as a pilot to ignite residual fuel oil. If all burners experience a flame failure, the initial burner is to be brought back in to automatic service only in the low-firing position. To avoid the possibility of false indication due to the failure of the flame scanner in the 'flame-on' mode, the initial light-off burner is to be fitted with dual scanners or a scanner of the self checking type.

3.1.3.5 Off-limit conditions of burner primary-air pressure or atomizing- steam pressure are to be alarmed at the main control location.

3.1.4 Boiler alarms and indications

3.1.4.1 Action of the automatic fuel oil or burner shut-off arrangement is to be indicated by audible and visual alarms. Means are to be provided to silence the audible alarms without canceling the visual indicator. Alarm systems are to be designed so that the alarm cannot remain silenced when the monitored system has returned to normal running condition.

3.1.4.2 Each boiler is to be fitted with one high-water level alarm and two independent low water-level sensors and alarms. The low-low water-level alarm is to close the master fuel oil cut- off for the boiler, and is to be set to operate when the water level falls to a minimum safe level, but at a level not lower than that visible in the gauge glass. Water-level sensors are to be so located as to minimize the effect of roll and pitch or they are to be provided with a short-time delay (approximately 5 seconds) to prevent trip-out due to transients or to the vessel's motion.

3.1.4.3 The alarms for forced-draft failure and for low-water level are to be installed in association with limiting controls which are to prevent start-up and cause shut-down when unsafe firing conditions exist. Manual resetting of the control system is to be required before the boiler can be restarted.

3.1.4.4 The operation status of the boiler is to be indicated at the boiler by conventional instruments, gauges, lights or other devices to show the functional condition of fuel, air, feed-water and steam circuits of boiler. Monitoring instruments are also to be provided at the main control location.

3.1.5 Logic sequence for boiler controls

3.1.5.1 Where automatically started boilers are installed, they are to be provided with a programmed control to assure a safe cycle of operation upon initial starting and cycling between temperature and pressure limits.

3.1.5.2 The programmed control is to be designed to cycle the boiler in accordance with a predetermined sequence and, in addition to the automatic boiler purge required by 3.1.3.2, is to include the following:-

a) Ignition (spark coming on) is to precede the opening of the fuel valve;

b) Where it is necessary to cut burners in and out to handle the load on the boiler and the controls are provided to modulate the air-fuel ratio, the automatic boiler purge period is to start with the modulating control in the high firing position and the ignition is not to be turned on until the modulating control has returned to the low-firing position.

3.1.5.3 Means are to be provided for independent manual control at the boiler in the event of failure of the automatic control and sufficient conventional instrumentation is to be provided so that satisfactory operation of the boiler under independent manual control can be exercised for lengthy periods of time.

3.2 Propulsion machinery

3.2.1 General

3.2.1.1 The fitting of centralized automatic controls for propulsion engines and turbines is not to impair the effectiveness of the safety and speed control devices required by the applicable parts of Ch.4.

3.2.1.2 Plant or engine response to throttle control demands is to be tested during trials and after final adjustment to demonstrate that no part of the plant or engine is jeopardized by the rate at which the throttle is moved from one extreme position to the other. Overriding of the remote throttle control is to be possible only from the main control location.

3.2.1.3 The emergency tripping of propulsion machinery is to be possible at the main control location and at the machine site.

3.2.2 Steam turbines

3.2.2.1 The astern guardian valve is to open automatically as a result of a throttle trip or a maneuvering signal, such as the actuation of a specific switch or by movement of the throttle control in the maneuvering range. An alarm is to indicate any failure of the guardian valve to open.

3.2.2.2 If scoop circulation is provided for the main condenser, the main circulating pump is to be automatically started as required for satisfactory operation of the propulsion machinery.

3.2.2.3 In the event of low lubricating-oil pressure there is to be an automatic changeover to the standby lubricating-oil pump(s). The governor is to be arranged to shut off the steam to the ahead turbines upon failure of the lubricating-oil system.

3.2.2.4 Alarms at the main control location are to indicate low vacuum in the condenser, excessive bearing temperature and low lubricating-oil pressure. Remote throttle control-system power failure indication is to be provided at the main control and secondary control locations. An alarm is to be provided at the main control and secondary control locations to indicate that the propeller shaft has been stopped too long on a standby or stop maneuver.

3.2.3 Gas turbines

3.2.3.1 Automatic control arrangements for gas turbine modules are to be provided to regulate the quantity of fuel flowing to the burners during starting, over the operating power range and when stopping the gas turbine, in a controlled manner and with in the safe operating envelope of the gas turbine. The arrangement is to have provision to collect, condition and transmit both primary and secondary surveillance signals to the local and remote operating locations.

3.2.3.2 The control system is to be provided with control functions at the component level to allow direct manual control of the fuel flow and engine shut down in the event of failure of the electrical power supplies or a critical failure of the engine control system.

3.2.3.3 Each gas turbine module is to be provided control unit comprising of minimum instrumentation necessary for monitoring, control and surveillance for safe operation both local and remote positions with facility for transfer of control authority through a suitable selector switch.

The alarms and automatic shut down devices to be provided are as indicated in Pt.4, Ch.4, Table 3.13.1.

3.2.4 Diesel engines

3.2.4.1 In the event of the lubricating oil pressure dropping to a preset level, there is to be an automatic changeover to a standby lubricating oil pump or a reduction in main engine speed to a predetermined level. In the event of a loss of lubricating oil pressure engines are to stop automatically.

3.2.4.2 Engine alarms are to be in accordance with Table 1.9.1 and Table 1.9.2.

3.2.4.3 Precautions are to be taken to ensure that it is not possible to continuously run the main engine in a barred speed range.

3.3 Emergency diesel engines

3.3.1 These requirements apply to diesel engines which are required to be immediately available in an emergency and capable of being controlled remotely or automatically operated. Information is to be submitted alongwith instructions to test alarm and safety systems demonstrating compliance with the requirements.

3.3.2 Alarms and safeguards are to be fitted in accordance with Table 3.3.2.

3.3.3 The safety and alarm systems are to be designed to ‘fail safe’. The characteristics of the ‘fail safe’ operation are to be evaluated on the basis not only of the system and its associated machinery, but also the complete installation, as well as the ship.

3.3.4 Regardless of the engine output, if shutdowns additional to those specified in Table 3.3.2 are provided except for the overspeed shutdown, they are to be automatically overridden when the engine is in automatic or remote control mode during navigation.

3.3.5 The alarm system is to function in accordance with Pt.5, Ch.22, with additional requirements that grouped alarms are to be arranged on the bridge. (See Pt.5, Ch.22, Cl.2.4.14).

3.3.6 In addition to the fuel oil control from outside the space, a local means of engine shutdown is to be provided.

3.3.7 Local indications of at least those parameters listed in Table 3.3.2 are to be provided within the same space as the diesel engines and are to remain operational in the event of failure of the alarm and safety systems.

Table 3.3.2 : Alarms and safeguards

Parameter	≥ 220 kW	< 220 kW
Fuel oil leakage from fuel injection pipes	Alarm activated	Alarm activated
Lubricating oil temperature	Alarm for high value	
Lubricating oil pressure	Alarm for low value	Alarm for low value
Oil mist concentration in crankcase[1]	Alarm for high value	
Pressure or flow of cooling water	Alarm for low value	
Temperature of cooling water (or cooling air)	Alarm for high value	Alarm for high value
Overspeed activated	Alarm activated + Shutdown	

Note 1 : For engines having a power of more than 2250 kW or a cylinder bore of more than 300 [mm].

Section 4

Tests and Trials

4.1 Individual components

4.1.1 The manufacturers of control systems are to certify that the mechanical, electrical, and solid-state components utilized have been satisfactorily tested individually or by acceptable lot sampling to establish their suitability for the intended service including their exposure to the following conditions :-

a) shipboard ambient conditions, See Ch.1, Sec.1;

b) ship motion and vibration as per 2.5;

c) temperature range as per 2.2;

d) voltage and frequency tolerances as per 2.2;

e) pressure tests as per 4.1.2 and 4.2.

4.1.2 Hydraulic and pneumatic piping is to be subjected to pressure tests at 1.5 times the relief-device settings using the service fluid in hydraulic systems and dry air or dry inert gas for pneumatic systems as the testing media. Means are to be provided for the automatic removal of moisture from the piping before delivery to the pneumatic control system.

4.1.3 All electrical control and monitoring circuits are to be checked and proven free of unintentional grounds and short circuits, defective electrical or electronic elements.

4.2 Shop testing

4.2.1 Upon completion of the control consoles or sections or component assemblies of such consoles, the manufacturer is to carry out tests in the presence of the Surveyor to demonstrate the satisfactory performance of all controls, instruments and alarms. The tests are to simulate all control and alarm functions given in the operational manual as far as practicable. The tests are to demonstrate satisfactory performance under the following conditions :

a) tests to be carried out at rated power supply at prevailing ambient air conditions;

b) loss of power to be simulated;

c) the voltage of the electrical supply to be varied plus or minus 10 per cent and where alternating current is used, the frequency is to be varied simultaneously to plus or minus 5 per cent. The controls are to function satisfactorily during these variations without faults. Where the components selected have been tested individually and are certified to function satisfactorily during these power variations, retesting of final assemblies will not be required;

d) all electrical circuits supplying power to servo-motors and actuators rated over 100 volts are to be subjected to dielectric-strength tests as required by Ch.8;

e) vibration tests required by 2.5 may be conducted in shops other than the plant of manufacture. When equipment is not energized during the test it is to perform satisfactorily after the vibration test;

f) variation of hydraulic or pneumatic system pressure $\pm$ 20 per cent of normal operating pressure, except that relief valve pressure need not be exceeded. The system is to operate satisfactorily at the relief valve pressure setting.

4.3 Trials on board

4.3.1 Upon completion of the installation, complete performance tests of all systems are to be carried out during dock trials and sea trials to demonstrate that the system will perform successfully during standby, maneuvering, steady conditions, and during transfer of controls.

4.3.2 A copy of the record of the trials is to be submitted for information. It is recommended that a copy of the record of the trials be kept on board for reference purposes for future adjustments/testing etc. The record should include details of all adjustments, calibrations, method of simulating failures and expected results due to these simulations. The record should be kept up to date at all times.

Section 5

Machinery Operated from a Centralised Control Station – ‘CCS’ Notation

5.1 General requirements

5.1.1 Where it is proposed to install control, alarm and safety systems to the following equipment, applicable features contained in Section 2 and Section 3 are to be incorporated in the system design.

- Propulsion machinery including essential auxiliaries;
- Electric power generating plant;
- Controllable pitch propellers;
- Oil fuel transfer and storage systems;
- Air compressors;
- Steam generating plant (boilers and their auxiliary equipment).

5.1.2 The arrangements are to be such that corrective actions can be taken at the control location in the event of machinery faults, e.g. stopping of machinery, starting of standby machinery, adjustments of operating parameters, etc. These actions may be effected by either remote manual or automatic control.

5.1.3 The controls, alarms and safeguards required by this chapter and Pt.5, Ch.22, as applicable, are to be provided at the control location. A fire detection system satisfying the requirements of Pt.5, Ch.22, Sec.2.13 is, also to be provided.

5.1.4 Additional requirements for controls, alarms and safeguards are given in 5.2.

5.2 Centralised control station for machinery

5.2.1 A centralized control station is to be provided at some suitable location, which satisfies the requirements of 5.2.2 to 5.2.7.

5.2.2 A system of alarm displays and controls is to be provided which readily ensures identification of faults in the machinery and satisfactory supervision and related equipment. The alarm and control systems are to satisfy the requirements of Section 1 and Section 2 as applicable.

5.2.3 Indication of all essential parameters necessary for the safe and effective operation of the machinery is to be provided, e.g. temperatures, pressures, tank levels, speeds, powers etc.

5.2.4 Indication of the operational status of running and standby machinery is to be provided.

5.2.5 At the centralized control station, means of communication with the bridge area, the accommodation for engineering personnel and if necessary, the machinery space are to be provided.

5.2.6 In addition to the communication required by 5.2.5, a second means of communication is to be provided between the bridge and the centralized control station. One of these means is to be independent of the main electrical power supply.

5.2.7 Arrangements are to be provided in the centralised control station so that the normal supply of electrical power may be restored in the event of failure.

Section 6

Programmable Electronic Systems

6.1 Scope

6.1.1 These requirements apply to the use of programmable electronic systems which provide control, alarm, monitoring or safety functions which are subject to classification.

6.1.2 The requirements given in this section do not apply to navigation and loading instruments.

6.2 General

6.2.1 Programmable electronic systems are to fulfill the requirements of the system under control for all normally anticipated operating conditions, taking into account human safety, environmental impact, damage to vessel as well as equipment, usability of programmable electronic systems and operability of non-computer devices and systems, etc.

6.2.2 Programmable electronic equipment is to revert to a defined safe state on initial start up or re-start in the event of failure.

6.2.3 In the event of failure of any programmable electronic equipment, the system and any other system to which it is connected, is to fail to a defined safe state or maintain safe operation, as applicable.

6.2.4 Where programmable electronic equipment shares resources, e.g. a data communication link, with any control, alarm or safety system for essential services or safety critical system, software is to meet the requirements of 6.3.1.5.

6.2.5 Emergency stops are to be hard-wired and independent of any programmable electronic equipment. Alternatively, the system providing emergency stop functions is to comply with the requirements of 6.3.1.1 and/or 6.3.1.5.

6.2.7 Programmable electronic equipment is to be provided with self-monitoring capabilities such that hardware and functional failures will initiate an audible and visual alarm in accordance with the requirements of 1.10 and where applicable 5.2. Hardware failures are to be indicated at least at module level.

6.2.8 System configuration, programs and data are to be protected against loss or corruption in the event of failure of any power supply.

6.2.9 Access to system configuration, programs and data is to be restricted by physical and/or logical means providing effective security against unathorised alteration.

6.2.10 Where date and time information is required by the equipment, this is to be provided by means of a battery powered clock with restricted access for alteration. Date and time of information is to be fully represented and utilized.

6.2.11 Displays and controls are to be protected against liquid ingress due to spillage or spraying.

6.2.12 User interfaces are to be designed in accordance with appropriate ergonomic principles to meet user needs and enable timely access to desired information or control of functions. A system overview is to be readily available.

6.2.13 The keyboard is to be divided logically into functional areas. Alphanumeric, paging and specific system keys are to be grouped separately.

6.2.14 Where a function may be accessed from more than one interface, the arrangement of displays and controls is to be consistent.

6.2.15 The size, colour and density of information displayed to the operator are to be such that information may be easily read from the normal operator position under all operational lighting conditions.

6.2.16 Display units are to comply with the requirements of International Electro technical Commission Standard IEC 950:1991, “Safety of information technology equipment, including electrical business equipment", in respect of emission of ionizing radiation.

6.2.17 Symbols used in mimic diagrams are to be visually representative and are to be consistent throughout the systems' displays.

6.2.18 Multi-function displays and controls are to be duplicated and interchangeable where used for the control or monitoring of more than one system, machinery or equipment. The number of units provided at the control location is to be sufficient to ensure continuing safe operation in the event of failure of any one unit. At least one unit at the main control location is to be supplied from an independent uninterruptible power supply (UPS).

6.2.19 When an alternative design or arrangements deviating from these requirements are proposed, an engineering analysis is required to be carried out in accordance with a relevant International or National Standard acceptable to IRS, See also SOLAS Ch.II-1/F, Reg.55.

Note : As a failure of a category III system may lead to an accident with catastrophic severity, the use of unconventional technology for such applications will only be permitted exceptionally in cases where evidence is presented that demonstrates acceptable and reliable system performance to the satisfaction of IRS.

6.3 Additional requirements for programmable electronic systems used for essential services and safety critical systems

6.3.1 The requirements of 6.3.1.1 to 6.3.1.7 are to be complied with where control, alarm or safety systems for essential services, as defined by Pt.4, Ch.8 or safety critical systems, incorporate programmable electronic equipment.

a) Safety critical systems are those which provide functions intended to protect persons from physical hazards, e.g. fire, explosion, etc. or to prevent mechanical damage which may result in the loss of an essential service, e.g. main engine low lubricating oil pressure shutdown.

b) Applications that are not essential services may also be considered to be safety critical, e.g. domestic boiler low water level shutdown.

6.3.1.1 Alternative means of operation are to be provided for essential services and wherever practicable, these are to be by provision of a fully independent hard wired backup system. Where these alternative means are dependent on any programmable electronic equipment, the software is to be certified by IRS.

6.3.1.2 The system is to be configured such that control, alarm and safety function groups are independent. A failure of the system is not to result in the loss of more than one of these function groups. Proposals for alternative arrangements providing an equivalent level of safety will be subject to special consideration.

6.3.1.3 For essential services, the system is to be arranged to operate automatically from an alternative power supply in the event of a failure of the normal supply.

6.3.1.4 Failure of any power supply is to initiate an audible and visual alarm in accordance with the requirements of 1.10.4 and where applicable, for SYJ Notation as given in Pt.5, Ch.22.

6.3.1.5 Where it is intended that the programmable electronic system implements emergency stop or safety critical functions, the software is to be certified by IRS. Alternative proposals providing an equivalent level of system integrity will be subject to special consideration, e.g. fully independent hard wired backup system, redundancy with design diversity, etc.

6.3.1.6 Control, alarm and safety related information is to be displayed in a clear, unambiguous and timely manner and where applicable, is to be given visual prominence over other information on the display.

6.3.1.7 Means of access to safety critical functions are to be dedicated to the intended function and readily distinguishable.

6.4 System categories

6.4.1 Programmable electronic systems are to be assigned into three system categories as shown in Table 6.4.1 according to the possible extent of the damage caused by a single failure within the system.

Consideration is to be given to the extent of the damage directly caused by a failure, but not to any consequential damage.

Identical redundancy will not be taken into account for the assignment of a system category.

6.4.2 The assignment of a programmable electronic system to the appropriate system category is to be made according to the greatest likely extent of direct damage. For examples see Table 6.4.2.

Note : Where independent effective backup or other means of averting danger is provided the system Category III may be decreased by one category.

Table 6.4.1 : System categories

Category	Effects	System functionality
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment	- Monitoring function for informational / administrative tasks
II	Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment	- Alarm and monitoring functions - Control functions which are necessary to maintain the ship in its normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment	- Control functions for maintaining the vessel's propulsion and steering - Safety functions

Table 6.4.2 : Examples of assignment to system categories

System category	Examples
I	Maintenance support systems Information and diagnostic systems
II	Alarm and monitoring equipment Tank capacity measuring equipment Control systems for auxiliary machinery Main propulsion remote control systems Fire detection systems Fire extinguishing systems Bilge systems Governors
III	Machinery protection systems / equipment Burner control systems Electronic fuel injection for diesel engines Control systems for propulsion and steering Synchronizing units for switchboards
The examples listed are not exhaustive.	

6.5 Data communication links

6.5.1 Where control, alarm or safety systems use shared data communication links to transfer data, the requirements of 6.5.2 to 6.5.12 are to be complied with. The requirements apply to local area networks, field buses and other types of data communication link which make use of a shared medium to transfer control, alarm or safety related data between distributed programmable electronic equipment or systems, for system Categories II and III.

6.5.2 Data communication is to be automatically restored within 45 seconds in the event of a single component failure. Upon restoration, priority is to be given to updating safety critical data and control, alarm and safety related data for essential services. Components comprise all items required to facilitate data communication, including cables, switches, repeater and power supplies.

6.5.3 Loss of a data communication link is not to result in the loss of ability to operate any essential service by alternative means, See also 6.5.2.

6.5.4 The properties of the data communication link, (e.g. bandwidth, access control method, etc.) are to ensure that all connected systems will operate in a safe, stable and repeatable manner under all operating conditions. The latency of control, alarm and safety related data is not to exceed two seconds.

6.5.5 Means are to be provided to protect the integrity of data and provide timely recovery of corrupted or invalid data.

6.5.6 The data communication link is to be of the self diagnosing type initiating an alarm upon detecting a failure on the link itself and data communication failures on nodes connected to the link. The audible and visual alarm is to operate in accordance with the requirements of 1.10.4 and where applicable, requirements as given in Pt.5, Ch.22 for SYJ notation in the event of a failure of an active or standby component.

6.5.7 System self-checking capabilities are to be arranged to initiate transition to the least hazardous state for the complete installation in the event of data communication failure.

6.5.8 The characteristics of the data communication link are to be such as to transmit all necessary information in adequate time and overloading is prevented.

6.5.9 Means are to be provided to prevent unintended connection or disconnection of any equipment where this may affect the performance of any other systems in operation.

6.5.10 Data cables are to comply with the applicable requirements of Pt.4, Ch.8. Other media will be subject to special consideration.

6.5.11 The installation is to provide adequate protection against mechanical damage and electromagnetic interference.

6.5.12 Components are to be located with appropriate segregation such that the risk of mechanical damage or electromagnetic interference resulting in the loss of both active and standby components is minimised. Duplicated data communication links are to be routed to give as much physical separation as is practical.

6.6 Additional requirements for wireless data links

6.6.1 These requirements are in addition to the requirements of 6.5.1 to 6.5.12 and apply to system category II using wireless data communication links to transfer data between distributed programmable electronic equipment or systems. For system category III, the use of wireless data communication links is to be in accordance with 6.2.19.

6.6.2 Functions that are required to operate continuously to provide essential services dependant on wireless data communication links are to have an alternative means of control that can be brought in action within an acceptable period of time.

6.6.3 Wireless data communication is to employ recognized international wireless communication system protocols that incorporate the following:

a) Message integrity. Fault prevention, detection, diagnosis and correction so that the received message is not corrupted or altered when compared to the transmitted message;

b) Configuration and device authentication. Is to only permit connection of devices that are included in the system design;

c) Message encryption. Protection of the confidentiality and or criticality of data content.

d) Security management. Protection of network assets, prevention of unauthorized access to network assets.

6.6.4 The wireless system is to comply with the radio frequency and power level requirements of International Telecommuni-cations Union and flag state requirements.

Note : Consideration should be given to system operation in the event of port state and local regulations that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication link due to frequency and power level restrictions.

6.7 Protection against modification

6.7.1 Programmable electronic systems of category II and III are to be protected against program modification by the user.

6.7.2 For systems of Category III modifications of parameters by the manufacturer are to be approved by IRS.

6.7.3 Any modifications made after performance of the tests witnessed by IRS as per item 6 in Table 6.8.1 are to be documented and traceable.

6.8 Documents to be submitted

6.8.1 For the evaluation of programmable electronic systems of category II and III, documents according to IEC 60092-504 paragraph 10.11 are to be submitted.

6.8.2 For all tests required in accordance with the system category, a test plan is to be submitted and the tests are to be documented.

6.8.3 Additional documentation may be required for systems of category III. The documentation is to include a description of the methods of test and test results.

6.8.4 Documents for the evaluation of programmable electronic systems of Category-I are to be submitted upon request.

6.8.5 Modifications are to be documented by the manufacturer. Subsequent significant modifications to the software and hardware for system categories II and III are to be submitted for approval.

6.8.6 When alternative design or arrangement is intended to be used, an engineering analysis is to be submitted in addition.

6.8.7 For wireless data communication equipment, the following additional information is to be submitted:

a) Details of manufacturers recommended installation and maintenance practices;

b) Communication network plan with arrangement and type of antennas and identification of location. This is to be shown in combination with other antennas on the vessel such as for GMDSS;

c) Specification of wireless communication system protocols and management functions;

d) Details of radio frequency and power levels of the equipment;

e) Evidence of type testing in accordance with IRS Classification Notes: ‘Type approval of Electrical Equipment used for Control, Protection, Safety and Internal Communication in Marine Environment’ ;

f) On-board test schedule, see 7.3.

6.9 Tests and conformance

6.9.1 Tests and conformance are to be in accordance with Table 6.9.1.

Table 6.9.1 : Tests and conformance according to the system category

No.	Tests and evidence	Systems Category		
		I	II	III
1.	**Evidence of quality system**			
	Quality plan for software		M	M
	Inspection of components (only hardware) from sub-suppliers		M	M
	Quality control in production		M	M
	Final test reports	M	M	S
	Traceability of software	M	M	S
2.	**Hardware and software description**			
	Software description		M	S
	Hardware description		M	S
	Failure analysis for safety related functions only			S
3.	**Evidence of software testing**			
	Evidence of software testing according to quality plan		M	S
	Analysis regarding existence and fulfillment of programming procedures for safety related functions			S
4.	**Hardware tests**			
	Tests according to classification notes		W	W
5.	**Software tests**			
	Module tests		M	S
	Subsystem tests		M	S
	System test		M	S
6.	**Performance tests**			
	Integration test		M	W
	Fault simulation		W	W
	Factory Acceptance Test (FAT)	M	W	W
7.	**On-board test**			
	Complete system test	M	W	W
	Integration test		W	W
	Operation of wireless equipment to demonstrate electromagnetic compatibility		W	W*
8.	Modifications			
	Tests after modifications	M	S/W	S/W

M = Evidence kept by manufacturer and submitted on request
S = Evidence checked by IRS
W = To be witnessed by IRS
* = The level of witnessing will be determined during the assessment required by 6.2.19.

Notes:

Definition and notes relating to Table 6.8.1 are as follows:

1. Evidence of quality system

1.1 Quality plan for software

A plan for software lifecycle activities are to be produced which defines relevant procedures, responsibilities and system documentation, including configuration management generally in accordance with ISO standard 90003 “Guidelines for the Application of ISO 9001:2000 to the Computer Software or Equivalent”.

1.2 Inspection of components (only Hardware) from sub-suppliers

Proof that components and/or sub-assemblies conform to specification.

1.3 Quality control in production
Evidence of quality assurance measures on production.

1.4 Final test reports
Reports from testing of the finished product and documentation of the test results.

1.5 Traceability of software
Modification of program contents and data, as well as change of version has to be carried out in accordance with a procedure and is to be documented.

2. Hardware and software description

2.1 Software description
Software is to be described, e.g.
- Description of the basic and communication software installed in each hardware unit
- Description of application software (not program listings)
- Description of functions, performance, constraints and dependencies between modules or other components.

2.2 Hardware description
Hardware is to be described, e.g.
- System block diagram, showing the arrangement, input and output devices and interconnections
- Connection diagrams
- Details of input and output devices
- Details of power supplies.

2.3 Failure analysis for safety related functions only (e.g. FMEA)
The analysis is to be carried out using appropriate means, e.g.
- Fault tree analysis
- Risk analysis
- FMEA or FMECA.

The purpose is to demonstrate that for single failures, systems will fail to safety and that systems in operation will not be lost or degraded beyond acceptable performance criteria when specified by IRS.

3. Evidence of software testing

3.1 Evidence of software testing according to quality plan.
Procedures for verification and validation activities are to be established, e.g.
- Methods of testing
- Test programs producing
- Simulation.

3.2 Analysis regarding existence and fulfillment of programming procedures for safety related functions
Specific assurance methods are to be planned for verification and validation of satisfaction of requirements, e.g.
- Diverse programs
- Program analysis and testing to detect formal errors and discrepancies of the description
- Simple structure.

4. Hardware tests

Tests according to Classification Notes “Type Approval of Electrical Equipment used for Control, Protection, Safety and Internal Communication in Marine Environment” are to be conducted. Special consideration may be given to tests witnessed and approved by another IACS member society.

5. Software tests

5.1 Module test
Software module tests are to provide evidence that each module performs its intended function and does not perform unintended functions.

5.2 Subsystem tests
Subsystems testing is to verify that modules interact correctly to perform the intended functions and do not perform unintended functions.

5.3 System test
System testing is to verify that subsystems interact correctly to perform the functions in accordance with specified requirements and do not perform unintended functions.

6. Performance tests

6.1 Integration tests
Programmable electronic system integration testing is to be carried out using satisfactorily tested system software and as far as practicable intended system components.

6.2 Fault simulation
Faults are to be simulated as realistically as possible to demonstrate appropriate system fault detection and system response. The results of any required failure analysis are to be observed.

6.3 Factory Acceptance Test (FAT)
Factory acceptance testing is to be carried out in accordance with a test program accepted by IRS. Testing is to be based on demonstrating that the system fulfils the requirements specified by IRS.

7. On-board tests

7.1 Complete system test
Testing is to be performed on the completed system comprising actual hardware components with the final application software, in accordance with an approved test program.

7.2 Integration tests
On board testing is to verify that correct functionality has been achieved with all systems integrated.

7.3 For wireless data communication equipment, tests during harbour and sea trials are to be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not itself fail as a result of electromagnetic interference during expected operating conditions.

Note : Where electromagnetic interference caused by wireless data communication equipment is found to be causing failure of equipment required for Category II or III systems, the layout and/or equipment is to be changed to prevent occurrence of further failures.

8. Modifications

8.1 Tests after modifications
Modifications to approved systems are to be notified in advance and carried out to Surveyor's satisfaction, see Cl. 6.3.5.

End of Chapter

Chapter 8

Electrical Installations

Contents

Section 1

General Requirements

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to both direct current and alternating current installations unless specifically stated otherwise.

1.1.2 The requirements of this Chapter apply to all ships. Consideration will be given to arrangements or details of equipment which comply with other National or International standards in so far as they are not less effective and reliable.

The arrangements for vessels intended for restricted services or for special services will be specially considered.

1.1.3 Whilst these requirements are considered to meet those of the "International Convention for the Safety of Life at Sea, 1974, including amendments", attention should also be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

1.2 Definitions

1.2.1 **Normal operational and habitable condition** is condition under which the ship as a whole, the machinery, services, means and aids ensuring propulsion, ability to steer, safe navigation, fire and flooding safety, internal and external communications and signals, means of escape and emergency boat winches, as well as designed comfortable conditions of habitability are in working order and functioning normally.

1.2.2 **Emergency condition** is a condition under which any services needed for normal operational and habitable conditions are not in a working order due to the failure of the main source of electrical power.

1.2.3 **Main source of electrical power** is a source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the ship in normal operational and habitable conditions.

1.2.4 **Main generating station** is the space in which the main source of electrical power is situated.

1.2.5 **Main switchboard** is a switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to ship's services.

1.2.6 **Emergency switchboard** is a switchboard which in the event of failure of the main electrical power supply system is directly supplied by the emergency source of electrical power or transitional source of emergency power and is intended to distribute electrical energy to the emergency services.

1.2.7 **Emergency source of electrical power** is a source of electrical power, intended to supply the emergency switchboard in the event of failure of the supply from the main source of electrical power.

1.3 Surveys

1.3.1 Electrical propelling machinery and associated equipment together with auxiliary services for the safety of the ship are to be installed in accordance with the relevant requirements of this Chapter, surveyed and have tests witnessed by the Surveyors.

1.3.2 All generators, motors and transformers of 100 [kW] and over, intended for essential services, are to be surveyed during test and if appropriate also during manufacturing.

Where an alternative survey scheme has been approved by IRS as per Ch.1, Sec.4, the attendance of the Surveyor during manufacturing may not be necessary.

1.3.3 All electric propelling machinery including switchgear, control gear, converting equipment, cables, main and auxiliary generators, motors and exciters are to be surveyed by the Surveyors during manufacture and testing.

1.3.4 For refrigerated cargo installations having HY class notation, motors are to be tested and certificates furnished by the manufacturers. Motors of 100 [kW] or over are to be surveyed by the Surveyors during manufacture and testing.

1.4 Plans

1.4.1 The following plans and details for electrical installations including propulsion equipment, if fitted, and auxiliary machinery are to be submitted in triplicate for approval:

a) Schematic diagram of the electrical system including information such as cable sizes, type of insulation, normal working currents, line drop of voltages and details of protection devices together with rating and interrupting capacity of circuit breakers and fuses;

b) Calculations of prospective short circuit current of main busbars and secondary side of transformers (Additionally load schedule is to be submitted for information);

c) Construction details, sectional views, type, rating, make of rotating machines rated at 100 [kW] and above, where welding is to be applied to shafts of machines and plans showing the construction;

d) The arrangement plans and circuit diagrams of switchgear and controlgear giving details of isolating, protective and control devices, details of bus bars, cable sizes, type of insulation and normal working currents in the circuits. Additional details such as mechanical stresses on the bus bars by short circuit, bus bar supporting arrangements, verification of protective devices;

e) General diagrams of emergency circuits, control and alarms for essential services and internal communications together with details of sources of supply, cable sizes and types of insulation and any other information required for assessment of such circuits;

f) Plans for generators, motors and seatings together with diagrams of control gears, cables and circuits for electric propulsion equipment, if fitted. Key diagram and explanation of the system are to be submitted;

g) Plans of electric slip couplings, if fitted, showing details of construction and scantlings together with diagrams of control gear and other electrical components;

h) For tankers and similar vessels, a general arrangement of the ship showing hazardous spaces and the location of the electrical equipment in such spaces. A schedule of safe type electrical equipment located in hazardous spaces giving details of the type of equipment fitted, the certifying authority and copies of the certificates.

1.4.2 Additional information may be required for vessels engaged in special services or of a novel design.

1.5 Essential and other services

1.5.1 Essential services

1.5.1.1 Essential services are divided into following types of services:

a) "Primary Essential Services" and

b) "Secondary Essential Services".

Definitions and examples of such services are given in 1.5.1.2 and 1.5.1.3.

1.5.1.2 Primary Essential Services

Primary Essential Services are those services which need to be in continuous operation to maintain propulsion and steering. Examples of equipment for primary essential services are as follows:

- Steering gears
- Pumps for controllable pitch propellers
- Scavenging air blower, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines and turbines necessary for propulsion
- Forced draught fans, feed water pumps, water circulating pumps, vacuum pumps and condensate pumps for steam plants on steam turbine ships, and also for auxiliary boilers on ships where steam is used for equipment supplying primary essential services
- Oil burning installations for steam plants on steam turbine ships and for auxiliary boilers where steam is used for equipment supplying primary essential services
- Azimuth thrusters which are the sole means for propulsion/steering and associated lubricating oil pumps, cooling water pumps
- Electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps
- Electric generators and associated power sources supplying the above mentioned equipment
- Hydraulic pumps supplying the above mentioned equipment
- Viscosity control equipment for heavy fuel oil
- Control, monitoring and safety devices/systems of equipment for primary essential services.

1.5.1.3 Secondary Essential Services

Secondary Essential Services are those services which need not necessarily be in continuous operation to maintain propulsion and steering but which are necessary for maintaining the vessel's safety. Example of equipment for secondary essential services are as follows:

- Windlass
- Fuel oil transfer pumps and fuel oil treatment equipment
- Lubricating oil transfer pumps and lubrication oil treatment equipment
- Pre-heaters for heavy fuel oil
- Starting air and control air compressors
- Bilge, ballast and heeling pumps
- Fire pumps and other fire extinguishing medium pumps
- Ventilating fans for engine and boiler rooms
- Services considered necessary to maintain dangerous spaces in a safe condition
- Navigation lights, aids and signals
- Internal safety communication equipment
- Fire detection and alarm system
- Lighting system
- Electrical equipment for watertight closing appliances
- Electric generators and associated power sources supplying the above equipment
- Hydraulic pumps supplying the above equipment
- Control, monitoring and safety systems for cargo containment systems
- Control, monitoring and safety devices / systems of equipment for secondary essential services.
- Equipment used for cooling and maintaining lesser ambient temperature (refer Ch.1, 1.7.4)

1.5.2 Services such as following are considered necessary for minimum comfortable conditions of habitability :

- cooking;
- heating;
- domestic refrigeration;
- mechanical ventilation;
- sanitary and fresh water;
- electric generators and associated power sources supplying the above mentioned equipment.

1.5.3 Services such as following, which are in addition to 1.5.1 and 1.5.2, are considered necessary to maintain the ship in a normal seagoing operational and habitable condition :

- cargo handling and cargo gear equipment;
- hotel services, other than those required for habitable conditions;
- thrusters, other than those for dynamic positioning.

1.6 Ambient reference conditions

1.6.1 For details regarding ambient reference conditions, See Ch.1.

1.7 Vibrations, accelerations

1.7.1 Electrical equipment is to be constructed to withstand when subjected to following :

vibrations within the frequency range 5 - 50 Hz and with vibration velocity amplitude 20 [mm/sec].

peak accelerations caused by the ship's movements in waves - ± 0.6 g for vessels of length exceeding 90 [m] and ± 1 g for other vessels.

1.7.2 All connections for current-carrying parts and earthing connections are to be fixed so that they cannot loosen by vibrations. This also applies to fixing of mechanical parts when found necessary.

1.8 Voltage and frequency variations

1.8.1 All electrical appliances supplied from the main or emergency systems are to be so designed and manufactured that they are capable of operating satisfactorily under the normally occurring variations in voltage and frequency. Unless otherwise stated in national or international standards, provided the variations comply with as stated below, all equipment are to operate satisfactorily with the variations from its rated value as shown in the following Tables 1.8.1 to 1.8.3.

a) For alternating current components; voltage and frequency variations shown in Table 1.8.1 are to be assumed.

b) For direct current components supplied by d.c. generators or converted by rectifiers, voltage variations shown in Table 1.8.2 are to be assumed.

c) For direct current components supplied by electrical batteries, voltage variations shown in Table 1.8.3 are to be assumed.

Table 1.8.1 : Voltage and frequency variations for a.c. distribution systems

Quantity in operation	Permanent variations	Transient variations
Frequency	± 5%	± 10% (recovery time 5 seconds)
Voltage	+ 6% - 10%	± 20% (recovery time 1.5 seconds)

Table 1.8.2 : Voltage variations for d.c. distribution systems

Parameters	Variations
Voltage tolerance (continuous)	±10%
Voltage cyclic variation deviation	5%
Voltage ripple (a.c., r.m.s., over steady d.c. voltage)	10%

Table 1.8.3 : Voltage variations for battery systems

Systems	Variations
Components connected to the battery during charging (see Note)	+30%, -25%
Components not connected to the battery during charging	+20%, -25%

Note : Different voltage variations as determined by the charging / discharging characteristics, including ripple voltage from the charging device, may be considered.

1.8.2 Any special system, e.g. electronic circuits, whose function cannot operate satisfactorily within the limits given in 1.8.1 are not be supplied directly from the system but by alternative means, e.g. through stabilized supply.

1.8.3 Contactors and similar electro-magnetic devices are not to drop out at or above 85 per cent rated voltage.

1.9 Location and construction

1.9.1 Electrical equipment is to be placed in accessible and adequately lighted spaces clear of flammable material and heat sources such as boilers, heated tanks etc. The spaces should be well ventilated, free from accumulations of flammable dusts, vapours or gases and acid fumes. The equipment should not be exposed to risk of mechanical injury or damage from water, excessive moisture, steam, oil or any other dangerous fluid. Where necessarily exposed to such hazards, the equipment is to be suitably constructed or enclosed.

1.9.2 Live parts are to be efficiently shielded from any accidental contact.

1.9.3 All electrical apparatus and equipment is to be constructed and installed so as to avoid injury or electrical shock when handled or touched in the course of normal operation.

1.9.4 Insulating materials and insulated windings are to be resistant to tracking, moisture, sea air, oil vapour and any other similar conditions, unless special precautions are taken to protect them.

1.9.5 Equipment is not to remain alive through the control circuits and/or pilot lamps when switched off by the control switch. This does not apply to synchronising switches and/or plugs.

1.9.6 The operation of all electrical equipment and the lubrication arrangements are to be efficient under such conditions of vibration and shock as arise in normal practice.

1.9.7 All nuts and bolts/screws used to connect or secure current- carrying parts and working parts are to be effectively locked, to prevent them from working loose due to vibration.

1.9.8 Generators, motors, conductors and generally any electrical equipment producing an external magnetic field are to be placed at such distance from the magnetic compass or any other equipment likely to be affected by such magnetic field or are to be so screened that the interfering external magnetic field is negligible (deviation less than 0.5°), even when circuits are switched on and off.

1.9.9 Where electric power is used for propulsion, the equipment is to be so arranged that it will operate satisfactorily in the event of partial flooding by bilge water above the tank top up to the floor plate level. See also Ch.3, Sec.2.

1.10 Design and construction

1.10.1 Design, construction and installation of electrical propelling machinery and associated equipment together with auxiliary services essential for the safety of ship are to be done in accordance with the relevant requirements of this Chapter and are to be surveyed and tested by the Surveyors.

1.10.2 Design and installation of other equipment is to be such as to ensure minimising the risk of fire due to its failure. As a minimum, it should comply with a National or International Standard, revised where necessary for ambient conditions.

1.10.3 Subject to inspection and testing by the Surveyors, compliance with the recommen-dations of the International Electrical

Commission (IEC) publication 92 : "Electro-technical Installation in Ships" or equivalent national standards, may be accepted as meeting the requirements of this Chapter.

1.10.4 Where the Rules require electrical equipment to be of a 'safe type', such equipment is to be certified for the gases/vapours involved. The construction and type testing is to be in accordance with IEC publication 79 : "Electrical Apparatus for Explosive Gas Atmospheres", or an equivalent national standard.

1.11 Voltages

1.11.1 Standard voltages as recommended by IEC for shipboard installations, will in general be accepted subject to the following limits :

a) For power and the heating equipment, permanently installed and connected to fixed wiring, except for space heaters (radiators) in accommodation spaces - 1000V;

b) For lighting (including signal lamps), space heaters in accommodation spaces, socket-outlets, portable appliances and other consumers supplied by flexible cables and for communication and instrumentation equipment - 250V.

1.11.2 The requirements of 1.11.1 may be waived for the following applications :

a) For permanently installed power and heating equipment, where connection by flexible cable is essential because of the application (e.g. for movable cranes and other hoisting gear), a maximum of 1000V is acceptable,

b) For portable appliances, which are not hand-held during operation (e.g. welding transformers, refrigerated containers), a maximum of 1000V with connection by flexible cable and socket outlet, which is interlocked with a switch. At each such socket outlet a precautionary warning is to be permanently and prominently displayed indicating the nature and voltage of the electric supply and the specific purpose for which the socket outlet is intended. Such arrangements may be installed for applications in 1.11.2(a) also,

c) For instrumentation and control equipment which are part of power and heating installations (e.g. pressure or temperature switches for start/stop of motors), a maximum of 1000V, provided that all components are constructed for this voltage. The wider choice available of such components suitable for a voltage upto 250V is not to be overlooked,

d) Internal circuits of radio, television and navigation equipment or the external transmission circuits of radio and radar equipment. These may be however subject to statutory regulations.

1.11.3 Installations with higher voltages than specified above may be accepted for special purposes (e.g. cold cathode discharge lamps, for large auxiliary machinery and for propulsion machinery) after special consideration, in each case, and subject to the provisions of Sec.13 of this Chapter.

1.12 Electrical equipment for use in explosive gas atmospheres

1.12.1 Where the Rules require electrical equipment to be of a "safe type", such equipment is to be certified for the gases/vapours involved. The equipment should conform to IEC publication 79, "Electrical Apparatus for Explosive Gas Atmospheres", or an equivalent national standard.

1.12.2 Certified safe type equipment includes the following types of protection :

Intrinsically safe	Ex "i"
Increased safety	Ex "e"
Flameproof	Ex "d"
Pressurized enclosure	Ex "p"

1.12.3 Further, lighting fittings of the air driven type with pressurized enclosures are considered to be a "safe type" of lighting fitting.

1.12.4 When "safe type" equipment is permitted in hazardous zones or spaces all switches and protective devices are to interrupt all lines or phases and, where practicable, are to be located in a non-hazardous zone or space unless specifically permitted otherwise. Appropriate labels of non-inflammable material are to be permanently affixed to such equipment, switches and protective devices for identification purposes.

1.13 Enclosures

1.13.1 The enclosure types given in Table 1.13.1 are required as a minimum.

Table 1.13.1 : Enclosure types in relation to location
(N : Normally not accepted for installation in this location)

Location	**Switchboards**	**Control gear and motor starters**	**Rotating machines**	**Transformers and rectifiers**	**Lighting fittings**	**Heating appliances**	**Socket outlets**	**Accessories such as switches connection boxes**
Engine and boiler rooms								
above the floor	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44
dry control rooms	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22
below the floor	N	N	IP 44	N	IP 44	IP 44	N	IP 44
closed compartments for fuel oil and lub.oil separators	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44	N	IP 44
Fuel oil tanks	N	N	N	N	N	N	N	N
Ballast and other water tanks, bilge wells	N	N	IP 68	N	N	IP 68	N	N
Ventilation ducts	N	N	IP 44	N	N	N	N	N
Deckhouses, forecastle spaces, steering gear compartments and similar spaces	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44
Ballast pump rooms and similar rooms below the loadline	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44	IP 56	IP 56
Cargo holds	N	N	IP 44	N	IP 55	N	IP 56	IP 56
Open deck, keel ducts	IP 56	IP 56	IP 56	IP 56	IP 55	IP 56	IP 56	IP 56
Battery rooms, lamp rooms, paint stores, stores for welding gas bottles	N	N	EX	N	EX	EX	N	EX
Dry accommodation spaces	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20
Batch rooms and showers	N	N	N	N	IP 44	IP 44	N	IP 56
Galleys, laundries and similar rooms	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44

1.13.2 *Installation of electrical and electronic equipment in engine rooms protected by fixed water-based local application fire-fighting systems (FWBLAFFS)*

Definitions:

Protected space:

- A machinery space where a FWBLAFFS is installed.

Protected areas:

- Areas within a protected space which is required to be protected by FWBLAFFS.

Adjacent areas:

- Areas, other than protected areas, exposed to direct spray.
- Areas, other than those defined above, where water may extend. See also Fig.1.13.2.

Electrical and electronic equipment enclosures located within areas protected by FWBLAFFS and those within adjacent areas exposed to direct spray are to have a degree of protection not less than IP44, except where evidence of suitability is submitted to and approved by IRS.

The electrical and electronic equipment within adjacent areas not exposed to direct spray may have a lower degree of protection provided evidence of suitability for use in these areas is submitted taking into account :

a) the design and equipment layout,
b) position of inlet ventilation openings, and
c) cooling airflow for the equipment.

Note :

1. Additional precautions may be required to be taken in respect of:

   a) tracking as the result of water entering the equipment.

   b) Potential damage as the result of residual salts from sea water systems.

   c) High voltage installations.

   d) Personnel protection against electric shock

2. Also refer to requirements indicated in Pt.6, Ch.3, Sec.4, Cl. 4.5.6.

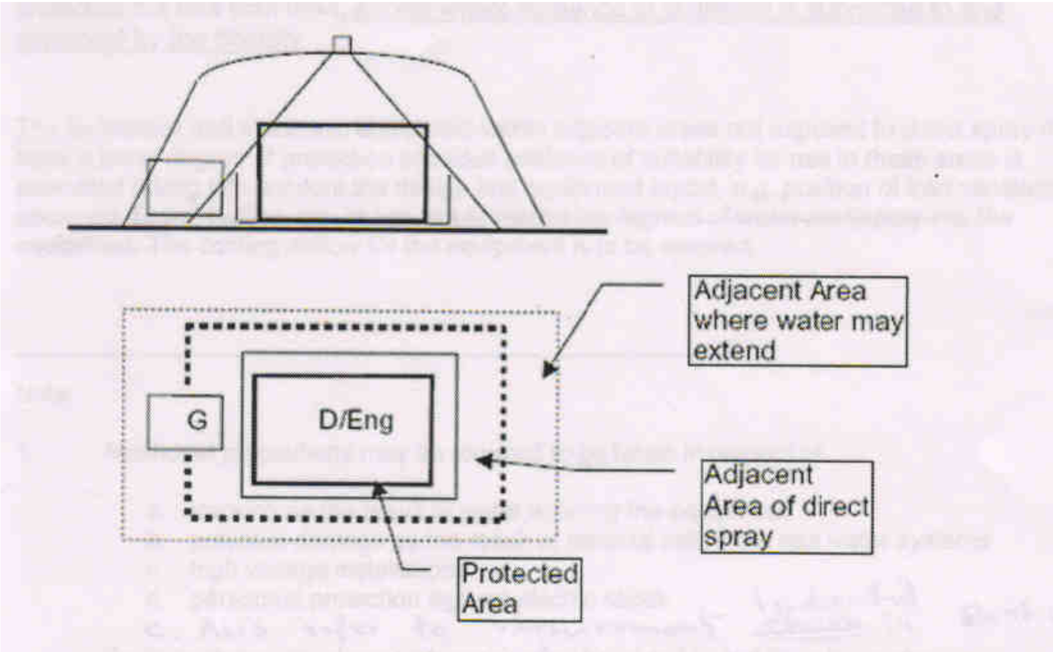


Fig. 1.13.2

1.14 Creepage and clearance

1.14.1 Distance between live parts and between live parts and earthed metal, whether across surfaces or in air, are to be adequate for the working voltages considering the nature of the insulating material and the transient over voltages developed by switch and fault conditions.

1.14.2 For bare busbars the minimum clearance distances in Table 1.14.1 are to be observed. Where necessary these distances are to be increased to allow for the electromagnetic forces involved.

Table 1.14.1 : Minimum clearances between bare busbars

Voltage between phases or poles	Minimum clearance to earth		Minimum clearance between phases or poles	
	In air [mm]	In oil [mm]	In air [mm]	In oil [mm]
660 or less	16	-	19	-
2200	38	-	38	-
3300	51	13	51	10
6600	63	19	89	25

1.15 Earthing of non-current carrying parts

1.15.1 Except where exempted by 1.15.2, all non-current carrying exposed metal parts of electrical equipment and cables are to be earthed.

1.15.2 The following parts may be exempted from the requirements of 1.15.1:

a) lamp-caps, where suitably shrouded;

b) shades, reflectors and guards supported on lamp holders or light fittings constructed of, or shrouded in, non-conducting material;

c) metal parts on, or screws in or through, non-conducting materials, which are separated by such material from current-carrying parts and from earthed non-current carrying parts in such a way that in normal use they cannot become live or come into contact with earthed parts;

d) apparatus which is constructed in accordance with the principle of double insulation;

e) bearing housings which are insulated in order to prevent circulation of current in the bearings;

f) clips for fluorescent lamps;

g) cable clips and short lengths of pipes for cable protection;

h) apparatus supplied at a voltage not exceeding 55 V direct current or 55 V, root mean square, between conductors, or between any conductor and earth in a circuit isolated from the supply. Auto transformers are not to be used for the purpose of achieving the alternating current voltage;

i) apparatus or parts of apparatus which although not shrouded in insulating material is nevertheless otherwise so guarded that it cannot be touched and cannot come in contact with exposed metal.

1.15.3 Metal coverings of cables are to be effectively earthed at both ends of the cable. In final sub-circuits, other than those installed in hazardous zones or spaces, earthing at the supply end only will be considered adequate. Single point earthing may be accepted for instrumentation cables, or cables for intrinsically safe circuits, if desirable for technical reasons.

1.15.4 The electrical continuity of all metal coverings of cables throughout the length of the cable, particularly at joints and trappings, is to be ensured.

1.15.5 Metal parts of portable appliances, other than current-carrying parts and parts exempted by 1.15.2 are to be earthed by means of an earth continuity conductor in the flexible cable or cord through the associated plug and socket outlet.

1.15.6 Earthing conductors are to be of copper or other corrosion-resistant material and be securely installed and protected where necessary against damage and also, where necessary, against electrolytic corrosion. Connections are to be so secured that they cannot work loose under vibration.

1.15.7 The nominal cross-section areas of copper earthing conductors are, in general to be equal to the cross-section of the current-carrying conductor upto 16 [mm^2]. Above this figure they are to be equal to at least half the cross-section of the current-carrying conductor with a minimum of 16 [mm^2]. Every other earthing conductor is to have a conductance not less than that specified for an equivalent copper earthing conductor.

1.15.8 The connection of the earthing conductors to the hull of the ship are to be made in accessible locations to permit their ready examination and to enable their disconnection for testing of insulation. They are to be secured by a screw or stud of diameter not less than 6 [mm] which is to be used for this purpose only. Bright metallic surfaces at the contact areas are to be ensured immediately before the nut or screw is tightened and where necessary, the joint is to be protected against electrolytic corrosion. The connection is to remain unpainted.

1.16 Bonding for the control of static electricity

1.16.1 Bonding straps for the control of static electricity are required for cargo tanks, process plant and piping systems, for flammable products and solids liable to release flammable gas and/or combustible dust, which are not permanently connected to the hull of the ship either directly or via their bolted or welded supports and where the resistance between them and the hull exceeds 1MΩ.

1.16.2 Where bonding straps are required for the control of static electricity, they are to be robust, that is, having a cross-sectional area of about 10 [mm^2] and are to comply with 1.15.6 and 1.15.8.

1.17 Operation under fire conditions

1.17.1 Electrical services required to be operable under fire conditions are as follows:

- Control and power systems to power-operated fire doors and their status indication.
- Control and power systems to power-operated watertight doors and their status indication.
- Emergency fire pump.
- Emergency lighting.
- Fire and general alarms.
- Fire detection systems.
- Fire-extinguishing systems and fire-extinguishing media release alarms.
- Low location lighting, see Pt.6, Ch.4, Sec.2.
- Public address systems.
- Remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and/or explosion.

1.17.2 Where cables for services as described in 1.17.1 including their power supplies, pass through high fire risk areas and in addition for passenger ships, main vertical fire zones, other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone. This may be achieved by either of the following measures:

a) Cables of a fire resistant type and complying with

i) IEC 60331-1 for overall diameter greater than 20 [mm] and

ii) IEC 60331-21 or IEC 60331-2 for overall diameter less than or equal to 20 [mm]

are installed and run continuously within the high fire risk area to keep the fire integrity. See Fig.1.17.2.

b) By running cables in two loops or distributing cables radially as widely apart as practicable and so arranged that in the event of damage by fire atleast one of loops or radial distributions remains operational.

Systems that are self monitoring, fail safe or duplicated with cable runs as widely separated as is practicable may be exempted.

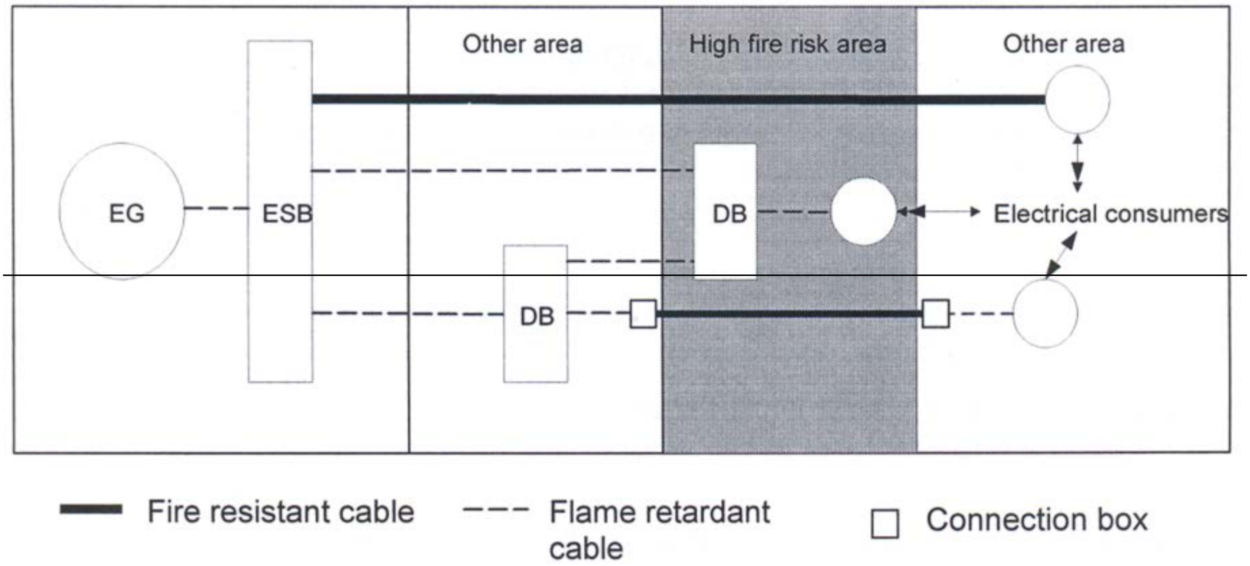


Fig.1.17.2 : The running of fire resistant type cables

1.17.3 The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps and their source(s) of power and prime mover(s). They are to be of a fire resistant type, in accordance with 1.17.2 (a), where they pass through other high fire risk areas.

1.17.4 "High fire risk areas" are defined as follows:

i) Machinery spaces as defined by Pt.6, Ch.1, 3.30, except spaces having little or no fire risk as defined in Pt 6, Ch 3, 3.2.2.3.2.2 (10) (including interpretations of table 9.3 to 9.8 given in MSC/Circ.1120).
ii) Spaces containing fuel treatment equipment and other highly flammable substances.
iii) Galley and pantries containing cooking appliances.
iv) Laundry with drying equipment.
v) Spaces as defined by paragraphs (8), (12) and (14) of Part 6, Chapter 3, Cl.3.2.2.3.2 for ships carrying more than 36 passengers.

1.18 Additions and alterations

1.18.1 Additions or alterations (temporary or permanent) to the approved load of the existing electrical installations are not to be made unless it has been ascertained that the current carrying capacity and condition of the existing installation are adequate for the proposed modification.

1.18.2 Plans for the proposed modifications are to be submitted for approval and the additions or alterations are to be carried out under the inspection and to the satisfaction of the Surveyors.

Section 2

System Design

2.1 General

2.1.1 Electrical installations are to be such that :

- all electrical auxiliary services necessary for maintaining the ship in normal operational and habitable conditions are ensured without recourse to the emergency source of electrical power;

- electrical services essential for safety are ensured under various emergency conditions; and

- the safety of passengers, crew and ship from electrical hazards is ensured.

2.2 Supply and distribution systems

2.2.1 The following systems of generation and distribution as detailed in Table 2.2.1 are acceptable.

2.2.2 Systems of generation and distribution, other than those specified above, will, upon application, be given special consideration.

2.3 Voltage and frequency variations

2.3.1 For installations supplied by generators, the voltage on the main switchboard's bus-bars is to be kept between 97.5 and 102.5 per cent of the installation's nominal voltage under all steady load conditions.

2.3.2 For D.C. installations supplied by batteries, consideration is to be given to the supply voltage variation between the battery's full-charged and minimum-charged voltages. For battery installations with "float charge", the maximum charging voltage is to be considered.

2.3.3 The transient voltage variations on the main switchboard's bus-bars by the maximum power and current variations which can occur (except under fault conditions), are not to exceed - 15% and + 20% of the nominal voltage.

2.3.4 The voltage drop in each consumer circuit, by full load on this circuit, is not to exceed 6% of the nominal voltage, measured from the main switchboard's bus-bars to the consumer. For battery circuits with supply voltage less than 50 Volts, 10% voltage drop may be accepted.

2.3.5 The frequency variations on AC installations are to be kept within the following limits :

- 95 - 105 per cent of rated frequency under steady load conditions; and

- 90 - 110 per cent of rated frequency under transient load conditions.

Table 2.2.1 : Systems of generation and distribution

Description	Tankers intended for the carriage in bulk of oil, liquefied gases and other hazardous liquids having a flashpoint not exceeding 60°C (closed cup test)	Other vessels
d.c. two wire insulated system (See Note 1)	Acceptable	Acceptable
a.c., single-phase, two wire insulated system (See Note 1)	Acceptable	Acceptable
a.c., three-phase, three wire insulated system (See Note 2)	Acceptable	Acceptable
a.c. or d.c. earthed systems	Normally not acceptable (See Note 3)	Acceptable
a.c. three-phase, four wire system with neutral earthed but without hull return	Not acceptable	Acceptable upto 1000V
Hull return system of distribution (a.c. or d.c.)	Normally not acceptable (See Notes 4 and 5)	Normally not acceptable (See Notes 4 and 5)

Note 1 : None of the poles/phases is earthed (see also para 2.4).

Note 2 : Neutral is not earthed.

Note 3 : This may be acceptable for -

a) Power supplied control circuits and instrumentation circuits, where technical or safety reasons require connection to earth, provided the current in the hull is limited to not more than 5 amps in both normal and fault conditions.

b) Earthed intrinsically safe circuits.

c) Limited and locally earthed systems, provided that any possible resulting current does not flow directly through any of the dangerous spaces.

d) Alternating current power networks of 1000 Volts root mean square (line to line) and over, provided that any possible resulting current does not flow directly through any of the dangerous spaces.

e) The electrical systems shall be specially considered for existing vessels built before 1st October, 1994.

Note 4 : This may be acceptable for -

a) Impressed current cathodic protection systems.

b) Limited and locally earthed systems, such as starting and ignition systems of internal combustion engines, provided that any possible resulting current does not flow directly through any of the dangerous spaces.

c) Insulation level monitoring devices, provided the circulation current does not exceed 30 mA under the most unfavourable conditions.

Note 5 : All final subcircuits, i.e. all circuits fitted after the last protective device are to be of two insulated wires the hull return being achieved by connecting to the hull, one of the busbars of the distribution board from which wires originate.

2.4 Earth indication

2.4.1 Every insulated distribution system is to be provided with a device or devices to continuously monitor the values of electrical insulation to earth and to give an audible or visual indication in case of abnormally low insulated values.

2.5 Number, arrangement and capacity of generators

2.5.1 The number and capacity of generators are to be such that with any one generator not in operation, the capacity of the remaining generators is to be sufficient for :

- supplying all essential and other services mentioned under 1.5.1 and 1.5.2 of this chapter which can be expected to be in use simultaneously, at full power on the propulsion plant, and including the maximum load which can be expected to occur on the lighting installation; and

- to have sufficient reserve capacity for starting the largest electric motor on board, without the transient voltage and frequency variations exceeding the values specified in 2.3.

2.5.2 For a duplicated essential or important consumer with only one unit driven electrically, it is not expected that electrically driven auxiliary would be used with one generator out of action. Similarly the loads due to side/bow thrusters are not to be taken in to account while calculating the electric load with one generator out of action unless necessitated by additional class notation regarding Dynamic Positioning.

2.5.3 The arrangement of the generators is to be such that the requirements of 2.5.1 would be met regardless of the speed and direction of the propulsion machinery or shafting.

2.5.4 In addition, the generating sets are to be such as to ensure that with any one generator or its primary source of power out of operation, the remaining generating sets are to be capable of providing the electrical services necessary to start the main propulsion plant from a dead ship condition. The emergency source of power may be used for the purpose of starting from a dead ship condition if its capability alone or combined with that of any other source of electrical power is sufficient to provide at the same time those services required to be supplied by 2.8.

2.5.5 Where the main source of electrical power is essential for the propulsion and steering of the ship, the system is to be arranged such that the electrical supply to equipment necessary for propulsion, steering and safety of the ship is maintained or immediately restored in case of loss of any one generator in service.

2.5.6 Requirement in 2.5.5 to be fulfilled by the following measures:

a) Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, provision of protection, including automatic disconnection of sufficient non-essential services and if necessary services those provided for habitability, should be made to ensure that, in case of loss of any of these generating sets, the remaining ones are kept in operation to permit propulsion and steering and to ensure safety.

b) Where the electrical power is normally supplied by one generator provision shall be made, upon loss of power, for automatic starting and connecting to the main switchboard of stand-by generator(s) of sufficient capacity with automatic restarting of the essential auxiliaries, in sequential operation if required. Starting and connection to the main switchboard of the stand-by generator is to be preferably within 30 seconds, but in any case not more than 45 seconds, after loss of power. Where prime movers with longer starting time are to be used, the starting and connection time are subject to special approval.

c) Load shedding or other equivalent arrangements should be provided to protect the generators against sustained overload.

i) The load shedding is to be automatic.

ii) Primary essential services mentioned in 1.5.1.2 are not to be included in any load shedding.

iii) The secondary essential services mentioned in 1.5.1.3 may be included in load shedding provided:

   a) Following systems, required for safety, are not disrupted:
      - lighting systems,
      - navigation lights, aids and signals,
      - internal safety communication equipment,
      - fire detection and alarm systems
      - electrical equipment for watertight closing appliances.

b) Immediate availability of following services, required for safety, is not affected when the power supply is restored to normal operating conditions:
   - fire pumps and other extinguishing medium pumps,
   - bilge pumps,
   - ventilating fans for engine and boiler rooms.

iv) The services for habitable conditions mentioned in 1.5.2 may be included in load shedding.

2.6 Prime movers for generators

2.6.1 Each generator required according to 2.5 is normally to be driven by a separate auxiliary prime mover. If such prime mover for a generator also is used for driving other auxiliary machinery, it is to have sufficient capacity for the total load, or the machinery arrangement is to be such that the generator and the other auxiliary machinery can not be used simultaneously.

If the other auxiliary machinery is connected to the prime mover in such a way that it is possible to overload the prime mover, an interlocking or other effective means for preventing such overloading is to be arranged.

2.6.2 When generators driven by reciprocating steam engines or steam turbines are used, and the operation of the boiler(s) depends on electric power supply, then there is to be at least one generator driven by an auxiliary oil engine or gas turbine to enable the boiler plant to be started.

2.6.3 Generators and generator systems, having the ship's main propulsion machinery as their prime mover, may be accepted as part of the ships main source of electrical power, provided:

a) They are capable of operating under all weather conditions during sailing and during manoeuvring, also when the vessel is stopped, within the limits of voltage and frequency variations as specified in 2.3;

b) Their rated capacity is safeguarded during all operations given above and is such that in the event of any other one of the generators failing, the services given in 1.5.1 and 1.5.2 are maintained;

c) The short circuit current of the generator / generator system is sufficient to trip the generator / generator system circuit-breaker taking into account the selectivity of the protective devices for the distribution system.

d) Protection is to be arranged in order to safeguard the generator / generator system in case of a short-circuit in the main bus bar. The generator / generator system is to be suitable for further use after fault clearance.

e) It is to be possible to disconnect the generator from the propulsion system by a separate clutch.

f) Starting of stand-by generating sets is to be in accordance with 2.5.6b).

2.6.4 Generators and generator systems, having the ship's propulsion machinery as their prime mover but not forming part of the ship's main source of electrical power as specified in 2.6.3a) may be accepted whilst the ship is at sea to supply electrical services required for normal operational and habitable conditions provided :

a) There are sufficient and adequately rated additional generators fitted, which constitute the main source of electrical power, meeting the requirements as specified in 2.5.3.

b) Means are provided to automatically start one or more of the generators, constituting the main source of electrical power as per 2.5.3 or 2.5.6b), upon the frequency variations exceeding ± 10 of the limits as specified in 2.3 and the voltage variations exceeding the limits as specified in 2.3.

c) The short circuit current of the generator and/or generator system is sufficient to trip the generator/generator system circuit-breaker taking into account the selectivity of the protective devices for the distribution system.

d) Where considered appropriate, load shedding arrangements are fitted to meet the requirements of 2.5.6c).

e) On ships having remote control of the ship's propulsion machinery from the navigating bridge means are provided, or procedures be in place, so as to ensure that supplies to essential services are maintained during manoeuvring conditions in order to avoid a blackout situation.

2.7 Number and capacity of transformers or power convertors

2.7.1 Where essential and other services mentioned under 1.5.1 and 1.5.2 of this chapter are supplied, by transformers or power convertors, the number and rating of transformers or power convertors are to be sufficient to ensure the operation of essential services and important consumers even when any one transformer or power convertor is out of action.

2.7.2 With any one transformer or power convertor out of action, the remaining transformer(s) or power convertor(s) should be adequate for starting the largest essential and important electric motor, without the transient voltage and frequency variations exceeding the limits specified in 2.3.

2.7.3 Each transformer or power convertor fitted in accordance with these requirement is to be installed as a separate unit, with a separate enclosure.

2.7.4 Each transformer is to be served by separate circuits on the primary and secondary sides. Auto transformers used for motor starting are excluded.

2.8 Emergency source of power

2.8.1 A self-contained emergency source of electrical power is to be provided in all ships.

2.8.2 The emergency source of electrical power and associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located above the uppermost continuous deck and are to be readily accessible from the open deck. They are not to be located forward of the collision bulkhead.

2.8.3 The location of the emergency source of electrical power and associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency electric lighting switchboards in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard are to be such as to ensure to the satisfaction of IRS that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard or in any machinery space of category A will not interfere with the supply, control and distribution of emergency electrical power. As far as practicable, the space containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard is not to be continuous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, or the main switchboard.

2.8.4 Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used exceptionally, and for short periods, to supply non-emergency circuits.

Exceptionally, whilst the vessel is at sea, is understood to mean conditions such as:

- blackout situation
- dead-ship situation
- routine use for testing
- short-term parallel operation with the main source of electrical power for the purpose of load transfer.

Unless instructed otherwise by the Administration the emergency generator may be used during lay time in port for the supply of the ship mains, provided the requirements of 2.8.4.1 and 2.8.4.2 below are complied with.

2.8.4.1 Requirements

a) To prevent the generator or its prime mover from getting overloaded when used in port, arrangements are to be provided to shed sufficient non-emergency loads to ensure its continued safe operation.

b) The prime mover is to be arranged with fuel oil filters and lubrication oil filters, monitoring equipment and protection devices as required for the prime mover for main power generation and for unattended operation.

c) The fuel oil supply tank to the prime mover is to be provided with a low level alarm, arranged at a level ensuring sufficient fuel oil capacity for the emergency services for the period of time as required by 2.8.8 and 2.8.9 of this section.

d) The prime mover is to be designed and built for continuous operation and should be subjected to a planned maintenance scheme ensuring that it is always available and capable of fulfilling its role in the event of an emergency at sea.

e) Fire detectors are to be installed in the location where the emergency generator set and emergency switchboard are installed.

f) Means are to be provided to readily change over to emergency mode from harbour mode.

g) Control, monitoring and supply circuits, for the purpose of the use of the emergency generator in port are to be so arranged and protected that any electrical fault will not influence the operation of the main and emergency services.

h) When necessary for safe operation, the emergency switchboard is to be fitted with switches to isolate the circuits.

2.8.4.2 Operation

Instructions* are to be provided on board to ensure that when the vessel is under way all control devices (e.g. valves, switches) are in a correct position for the independent emergency operation of the emergency generator set and emergency switchboard.

* These instructions are also to contain information on required fuel oil tank level, position of harbour/sea mode switch if fitted, ventilation openings etc.

2.8.5 The emergency generator and other means needed to restore the propulsion are to have a capacity such that the necessary propulsion starting energy is available within 30 minutes of blackout/dead ship condition. For the purpose of this requirement "Blackout" is to be understood to mean a "dead ship" condition. Emergency generator stored starting energy is not to be directly used for starting the propulsion plant, the main source of electrical power and/or other essential auxiliaries (emergency generator excluded). The requirement of propulsion starting energy being available within 30 minutes would remain applicable even when there is no emergency generator installed.

For steam ships, the 30 minute time limit is the time from blackout / dead ship condition to lighting of the first boiler.

2.8.6 Use of emergency generator during lay time in port for the supply of the ship mains as stated in para 2.8.4 will be specially considered on submission of details of safeguards to ensure its continued availability for its intended emergency duties.

2.8.7 Starting arrangements for emergency generating sets

2.8.7.1 Emergency generating sets are to be capable of being readily started in their cold condition at a temperature of 0°C. If this is impracticable, or if lower temperatures are likely to be encountered, provision acceptable to IRS is to be made for the maintenance of heating arrangements, to ensure ready starting of the generating sets.

2.8.7.2 Each emergency generating set arranged to be automatically started is to be equipped with starting devices approved by IRS with a stored energy capability of at least three consecutive starts. A second source of energy is to be provided for an additional three starts within 30 minutes unless manual starting can be demonstrated to be effective.

2.8.7.3 The stored energy is to be maintained at all time, as follows:

a) electrical and hydraulic starting systems are to be maintained from the emergency switchboard;

b) compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard;

c) all of these starting, charging and energy storing devices are to be located in the emergency generator space; these devices are not to be used for any purpose other than the operation of the emergency generating set. This does not preclude the supply to the air receiver of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

2.8.7.4 Where automatic starting is not required, manual starting is permissible, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or powder charge cartridges, where they can be demonstrated as being effective.

2.8.7.5 When manual starting is not practicable, the requirements of 2.8.7.2 and 2.8.7.3 are to be complied with except that starting may be manually initiated.

2.8.8 Passenger ships

2.8.8.1 The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified herein, if they depend upon an electrical source for their operation:

a) For a period of 36 hours, emergency lighting:

i) at every embarkation station on deck and over sides;

ii) in alleyways, stairways and exits giving access to the muster and embarkation stations;

iii) in all service and accommodation alleyways, stairways and exits, personnel lift cars;

iv) in the machinery spaces and main generating stations including their control positions;

v) in all control stations, machinery control rooms, and at each main and emergency switchboard;

vi) at all stowage positions for firemen's outfits;

vii) at the steering gear; and

viii) at the fire pump, the sprinkler pump and the emergency bilge pump referred to in 2.8.8.1(d) and at the starting position of their motors.

b) For a period of 36 hours

i) the navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force; and

ii) on ships constructed on or after 1 February 1995, the VHF radio installation; and if applicable

- the MF radio installation;
- the ship earth station; and
- the MF/HF radio installations.

c) For a period of 36 hours; unless such services have an independent supply for the period of 36 hours from an accumulator battery suitably located for use in an emergency:

i) all internal communication equipment required in an emergency which is generally;

- The means of communication which is provided between the navigating bridge and the steering gear compartment.
- The means of communication which is provided between the navigating bridge and the position in the machinery space or control room from which the engines are normally controlled.
- The means of communication which is provided between the bridge and the radio telegraph or radio telephone stations.
- The means of communication which is provided between the officer of the watch and the person responsible for closing any watertight door which is not capable of being closed from a central control station.
- The public address system or other effective means of communication which is provided throughout the accommodation, public and service spaces.
- The means of communication which is provided between the navigating bridge and the main fire control station.

ii) the shipborne navigational equipment, where such provision is unreasonable or impracticable IRS may waive this requirement for ships of less than 5,000 tons gross tonnage;

iii) the fire detection and fire alarm system, and the fire door holding and release system; and

iv) for intermittent operation of the daylight signaling lamp, the ship's whistle, the manual fire alarms and all internal signals that are required in an emergency.

d) For a period of 36 hours:

i) one of the fire pumps required by Ch.9;

ii) the automatic sprinkler pump, if any; and

iii) the emergency bilge pump and all the equipment essential for the operation of electrically powered remote controlled bilge valves.

e) For the period of time required by Ch.6, Sec.6, the steering gear if required to be so supplied.

f) For a period of half an hour:

i) any watertight doors which are required to be power operated together with their indicators and warning signals. Sequential operation of the doors may be permitted provided all doors can be closed in 60 seconds;

ii) the emergency arrangements to bring the lift cars to deck level for the escape of persons. The passenger lift cars may be brought to deck level sequentially in an emergency.

g) In a ship engaged regularly on voyages of short duration, IRS if satisfied that an adequate standard of safety would be attained may accept a lesser period than the 36 hour period specified in 2.8.8.1(a) to 2.8.8.1(e) but not less than 12 hours.

2.8.8.2 The emergency source of electrical power may be either a generator or an accumulator battery, which is to comply with the following:

a) Where the emergency source of electrical power is a generator, it is to be:

i) driven by a suitable prime-mover with an independent supply of fuel having a flashpoint (closed cup test) of not less than 43°C;

ii) started automatically upon failure of the electrical supply from the main source of electrical power and is to be automatically connected to the emergency switchboard; those services referred to in 2.8.8.3 are then to be transferred automatically to the emergency generating set. The automatic starting system and the characteristic of the prime-mover are to be such as to permit the emergency generator to carry its full rated load as quickly as is safe and practicable, subject to a maximum of 45 seconds; unless a second independent means of starting the emergency generating set is provided, the single source of stored energy is to be protected to preclude its complete depletion by the automatic starting system; and

iii) provided with a transitional source of emergency electrical power according to 2.8.8.3.

b) Where the emergency source of electrical power is an accumulator battery, it is to be capable of:

i) carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage;

ii) automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and

iii) immediately supplying at least those services specified in 2.8.8.3.

2.8.8.3 The transitional source of emergency electrical power required by 2.8.8.2(a)(iii) is to consist of an accumulator battery suitably located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage and be of sufficient capacity and so arranged as to supply automatically in the event of failure of either the main or emergency source of electrical power at least the following services, if they depend upon an electrical source for their operation:

a) For half an hour:

i) the lighting required by paragraphs 2.8.8.1(a) and 2.8.8.1(b)(i);

ii) Services required by paragraphs 2.8.8.1(c) (i, iii and iv) unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

b) Power to close the watertight doors but not necessarily all of them simultaneously, unless an independent temporary source of stored energy is provided. Power to the control, indication and alarm circuits as required for half an hour.

2.8.8.4 Where the emergency and/or transitional emergency loads are supplied from a battery via an electronic converter or inverter the maximum permitted voltage variations are to be taken as those on the load side of the converter or inverter.

The above mentioned voltage variants are not to exceed the following limits, as applicable:

a) Where the system on the load side of the converter or inverter is d.c. : limits as given in 2.8.8.3.

b) Where the system on the load side of the converter or inverter is a.c. : limits as given in 1.8.1.

2.8.8.5 The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

2.8.8.6 Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

2.8.8.7 No accumulator battery fitted in accordance with this Section is to be installed in the same space as the emergency switchboard. An indicator is to be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power referred to in paragraph 2.8.8.2(b) or 2.8.8.3 are being discharged.

2.8.8.8 The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be adequately protected at the main switchboard against overload and short circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short circuit.

2.8.8.9 In order to ensure ready availability of the emergency source of electrical power, arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that power will be available to the emergency circuits.

2.8.8.10 The emergency generator and its prime-mover and any emergency accumulator battery is to be so designed and arranged as to ensure that they will function at full rated power when the ship is upright and when inclined at any angle of list up to 22.5° or when inclined up to 10° either in the fore or aft direction, or is in any combination of angles within those limits.

2.8.8.11 Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements.

2.8.9 Cargo ships

2.8.9.1 The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified herein, if they depend upon an electrical source for their operation:

a) For a period of 3 hours, emergency lighting at every muster and embarkation station and over sides;

b) For a period of 18 hours, emergency lighting:

i) in all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks;

ii) in the machinery spaces and main generating stations including their control positions;

iii) in all control stations, machinery control rooms, and at each main and emergency switchboard;

iv) at all stowage positions for firemen's outfits;

v) at the steering gear;

vi) at the fire pump referred to in 2.8.9.2, at the sprinkler pump, if any, and at the emergency bilge pump, if any, and at the starting positions of their motors; and

vii) in all cargo pump-rooms of tankers.

c) For a period of 18 hours

i) the navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force; and

ii) on ships constructed on or after 1 February 1995, the VHF radio installation; and if applicable

- the MF radio installation;
- the ship earth station; and
- the MF/HF radio installations.

d) For a period of 18 hours; unless such services have an independent supply for the period of 18 hours from an accumulator battery suitably located for use in an emergency:

i) all internal communication equipment as required in an emergency which is generally as indicated in 2.8.8.1 c) i);

ii) the shipborne navigational equipment, where such provision is unreasonable or impracticable IRS may waive this requirement for ships of less than 5,000 tons gross tonnage;

iii) the fire detection and fire alarm system; and

iv) intermittent operation of the daylight signaling lamp, the ship's whistle, the manual fire alarms, and all internal signals that are required in an emergency.

2.8.9.2 For period of 18 hours one of the fire pumps required by Pt.6, Ch.3, if dependent upon the emergency generator for its source of power.

2.8.9.3 For the period of time required by Ch.6, Sec.6, the steering gear where it is required to be so supplied.

2.8.9.4 In a ship engaged regularly in voyages of short duration, IRS if satisfied that an adequate standard of safety would be attained may accept a lesser period than the 18 hour period specified in paragraphs 2.8.9.1(b) to 2.8.9.1(d) and 2.8.9.2 but not less than 12 hours.

2.8.9.5 The emergency source of electrical power may be either a generator or an accumulator battery, which is to comply with the following:

a) Where the emergency source of electrical power is a generator, it is to be:

i) driven by a suitable prime-mover with an independent supply of fuel, having a flashpoint (closed cup test) of not less than 43°C;

ii) started automatically upon failure of the main source of electrical power supply unless a transitional source of emergency electrical power in accordance with 2.8.9.5(a)(iii) is provided; where the emergency generator is automatically started, it is to be automatically connected to the emergency switchboard; those services referred to in 2.8.9.6 are then to be connected automatically to the emergency generator; and unless a second independent means of starting the emergency generator is provided the single source of stored energy is to be protected to preclude its complete depletion by the automatic starting system; and

iii) provided with a transitional source of emergency electrical power as specified in 2.8.9.6 unless an emergency generator is provided capable both of supplying the services mentioned in 2.8.9.6 and of being automatically started and supplying the required load as quickly as is safe and practicable subject to a maximum of 45 seconds.

b) Where the emergency source of electrical power is an accumulator battery it is to be capable of:

i) carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage;

ii) automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and

iii) immediately supplying at least those services specified in 2.8.9.6.

2.8.9.6 The transitional source of emergency electrical power where required by 2.8.9.5(a) is to consist of an accumulator battery suitably located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage and be of sufficient capacity and is to be so arranged as to supply automatically in the event of failure of either the main or the emergency source of electrical power for half an hour at least the following services if they depend upon an electrical source for their operation:

a) the lighting required by 2.8.9.1(a) to 2.8.9.1(c). For this transitional phase, the required emergency electric lighting, in respect of the machinery space and accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps; and

b) all services required by 2.8.9.1(d) (i, iii and iv) unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

2.8.9.7 Where the emergency and/or transitional emergency loads are supplied from a battery via an electronic converter or inverter the maximum permitted voltage variations are to be taken as those on the load side of the converter or inverter.

The above mentioned voltage variants are not to exceed the following limits, as applicable:

a) Where the system on the load side of the converter or inverter is d.c. : limits as given in 2.8.9.6.

Where the system on the load side of the converter or inverter is a.c. : limits as given in 1.8.1.

2.8.9.8 The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

2.8.9.9 Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

2.8.9.10 No accumulator battery fitted in accordance with this Section is to be installed in the same space as the emergency switchboard. An indicator is to be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of electrical power referred to in paragraph 2.8.9.5(b) or 2.8.9.6 are being discharged.

2.8.9.11 The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be adequately protected at the main switchboard against overload and short circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short circuit.

2.8.9.12 In order to ensure ready availability of the emergency source of electrical power, arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that electrical power will be available automatically to the emergency circuits.

2.8.9.13 The emergency generator and its prime-mover and any emergency accumulator battery is to be so designed and arranged as to ensure that they will function at full rated power when the ship is upright and when inclined at any angle of list up to 22.5° or when inclined up to 10° either in the fore or aft direction, or is in any combination of angles within those limits. Also refer to Part 4, Chapter 1, Table 1.7.1.

2.8.9.14 Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements.

2.9 Requirements for uninterrupted power system (UPS) units as alternative and/or transitional source of power

2.9.1 Scope

These requirements to UPS units, as defined in IEC 62040, apply when providing an alternative power supply or transitional power supply to services as defined in 2.8.8 and 2.8.9.

A UPS unit complying with these requirements may provide an alternative power supply as an accumulator battery in terms of being an independent power supply for services defined in 2.8.8.1c) and 2.8.9.1d).

2.9.2 Definitions

Uninterruptible Power System (UPS) – combination of converters, switches and energy storage means, for example batteries, constituting a power system for maintaining continuity of load power in case of input power failure (IEC 62040:1999).

Off-line UPS unit – a UPS unit where under normal operation the output load is powered from the bypass line (mains) and only transferred to the inverter if the bypass supply fails or goes outside preset limits. This transition will invariably result in a brief (typically 2 to 10 milli-seconds) break in the load supply.

Line interactive UPS unit – an off-line UPS unit where the bypass line switches to stored energy power when the input power goes outside the preset voltage and frequency limits.

On-line UPS unit – a UPS unit where under normal operation the output load is powered from the inverter and will therefore continue to operate without break in the event of the supply input failing or going outside preset limits.

2.9.3 Design and construction

a) UPS units are to be constructed in accordance with IEC 62040 or an acceptable and relevant national or international standard.

b) The operation of the UPS is not to depend upon external services.

c) The type of UPS unit employed, whether off-line, line interactive or on-line, is to be appropriate to the power supply requirements of the connected load equipment.

d) An external bypass is to be provided.

e) The UPS unit is to be monitored and audible and visual alarm is to be given in a normally attended location for –

   - Power supply failure (voltage and frequency) to the connected load,
   - Earth fault,
   - Operation of battery protective device,
   - When the battery is being discharged, and
   - When the bypass is in operation for on-line UPS units.

2.9.4 Location

a) The UPS unit is to be suitably located for use in an emergency.

b) UPS units utilizing valve regulated sealed batteries may be located in compartments with normal electrical equipment, provided the ventilation arrangements are in accordance with the requirements to IEC 62040 or an acceptable and relevant national or international standard.

2.9.5 Performance

a) The output power is to be maintained for the duration required for the connected equipment as stated in 2.8.8 and 2.8.9.

b) No additional circuits are to be connected to the UPS unit without verification that the UPS unit has adequate capacity. The UPS battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in the regulations.

c) On restoration of the input power, the rating of the charge unit shall be sufficient to recharge the batteries while maintaining the output supply to the load equipment.

2.9.6 Testing and survey

a) UPS units of 50 kVA and over are to be surveyed during manufacturing and testing.

b) Appropriate testing is to be carried out to demonstrate that the UPS unit is suitable for its intended environment. This is expected to include as a minimum the following tests:

   - Functionality, including operation of alarms;
   - Temperature rise;
   - Ventilation rate
   - Battery capacity.

c) Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by an appropriate test.

2.10 Essential services

2.10.1 Where essential services are duplicated, they are to be served by individual circuits separated throughout their length as widely as is practicable and without the use of common feeders, protective devices or control circuits.

2.11 Diversity factor

2.11.1 Circuits supplying two or more final sub-circuits are to be rated in accordance with the total connected load subject, where justified, to the application of a diversity factor. Where spare ways (feeders) are provided on a section or distribution board, an allowance for future increase of load is to be added to the total connected load before application of any diversity factor.

2.11.2 The diversity factor may be applied when calculating cable size and when calculating the rating of switchgear and fusegear.

2.11.3 The Diversity factors are not applicable to supply cables to distribution switchboards for lighting and heating.

2.11.4 The calculation of the diversity factor is to be submitted along with all relevant data.

2.12 Lighting circuits

2.12.1 Lighting circuits are to be supplied by final sub-circuits, which are separate from those for heating and power. This provision need not be applied to cabin fans and small wardrobe heaters.

2.12.2 A final sub-circuit of rating exceeding 15 A is not to supply more than one point.

2.12.3 A final sub-circuit of rating 15 A or less is not to supply more than the following number of lighting points:-

10 for ………. 24 - 55 V circuits

14 for ………. 110 - 127 V circuits

24 for ………. 220 - 250 V circuits.

This provision is not applicable to final sub-circuits for cornice lighting, panel lighting and electric signs where lampholders are closely grouped; in such cases, the number of points is unrestricted provided the maximum operating current in the sub-circuit does not exceed 10 A.

2.12.4 Lighting for machinery spaces, control stations, work spaces, public spaces, corridors and stairways leading to boat decks should be supplied from at least two final sub-circuits in such a way that failure of any one of the circuits does not leave the spaces in darkness.

2.12.5 For lighting in hazardous areas, switches are to be of the double-pole type and wherever practicable, located in a non-hazardous area. If fitted in hazardous areas, these switches are to be of flameproof type.

2.12.6 Lighting of unattended spaces, such as cargo spaces and coal bunkers, is to be controlled by multi-pole linked switches located outside such spaces. Provision is to be made for the complete isolation of these circuits and locking in the "OFF" position of the means of control.

2.12.7 The arrangement of the main electric lighting system is to be such that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard, will not render the emergency lighting system inoperative.

2.13 Motor circuits

2.13.1 A separate final sub-circuit is to be provided for every motor required for essential services and for every motor of 1 [kW] or more.

2.13.1 Motors of permanently installed submersible bilge pumps are to be connected to the emergency switchboard, (if fitted).

2.13.2 Cables and their connections to such pumps are to be capable of operating under a head of water equal to their distance below the bulkhead deck. The cables are to be suitable for operation in permanently wet situations, and installed in continuous lengths from above the bulkhead deck to the motor terminals.

2.13.3 Under all circumstances it is to be possible to start the motor of a permanently installed submersible bilge pump from a position above the bulkhead deck.

If an additional starter is provided at the motor, it is to be so arranged as to permit, in all cases, remote starting.

2.14 Motor controls

2.14.1 Every electric motor is to be provided with an efficient means of starting and stopping so placed as to be easily accessible to the person controlling the motor.

2.14.2 Every motor required for essential services and every motor of 0.5 [kW] or more is to be provided with the control apparatus as mentioned in 2.14.4 to 2.14.8.

2.13.3 When motor control gear is being selected, the maximum current of the motor is to be taken as its rated full load current.

2.14.4 Efficient means of isolation are to be provided so that all voltage may be cut off from the motor and any associated apparatus including any automatic circuit breaker.

2.14.5 Where the primary means of isolation (viz. that provided at the switchboard, section board or distribution fuse board) is remote from a motor, one of the following provisions is to be made :

a) An additional means of isolation fitted adjacent to the motor; or

b) Provision made for locking the primary means of isolation in the OFF position; or

c) Provision made so that the fuses in each line can be readily removed and retained by authorized personnel.

2.14.6 Means to prevent the undesired restarting after a stoppage due to low volts or complete loss of volts are to be provided. This does not apply to motors where a dangerous condition might result from the failure to restart automatically e.g. steering gear motor. It is, however, to be ensured that the total starting current of motors having automatic re-start will not cause excessive voltage drop or overcurrent on the installation.

2.14.7 Means for automatic disconnection of the supply in the event of excess current due to mechanical overloading of the motor are to be provided. (This does not apply to steering gear motors and thruster motors. Overload alarms are to be provided for these motors. For requirements regarding steering gear motors, See Ch.6).

2.14.8 Where fuses are installed to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overload in the case of single phasing.

2.15 Remote stops for ventilation fans and pumps

2.15.1 Ventilating fans for machinery spaces are to be provided with means for stopping them from easily accessible control stations located outside such spaces. (Also refer Pt.6, Ch.2, 2.2.1.2).

2.15.2 Motors driving forced and induced draught fans, independently driven pumps delivering oil to main propulsion machinery for bearing lubrication and piston cooling, oil fuel transfer pumps, oil fuel unit pumps and other similar fuel pumps, fuel and lubricating oil purifiers and their attached pumps are to be fitted with remote controls situated outside the space concerned so that the electrical supply thereto can be disconnected in the event of fire arising in the space in which they are located. (Also refer Ch.3, Cl. 4.11.1) and Pt.6, Ch.2, Sec.2.

2.15.3 Where overboard discharges from cooling water or similar pumps are likely to jeopardize the safe launching of lifeboats or life rafts, under any condition of loading of the ship, then the motors driving these pumps are to be provided with suitably located remote shut-off arrangements.

2.16 Fire detection and extinguishing systems

2.16.1 Electrical equipment used in operating fire detecting systems is to be served by two circuits, one fed from the main power supply system and the other from the emergency power supply system. These feeders are to be connected to an automatic change-over switch installed in the vicinity of the fire detection panel.

2.16.2 Where an electrically driven fire pump is supplied power from the emergency switchboard, the supply cable to such pump is not to pass through the main machinery spaces.

2.17 Lift circuits

2.17.1 Lifts or hoists to be used by passengers and/or crew are to be supplied from the main switchboard, either directly or through a section board, by circuits which do not supply any other appliance.

2.17.2 Cable or cables supplying current to motors of lifts or hoists are not to be incorporated within the flexible trailing cable used in connection with the control and safety devices.

2.18 Heating and cooking equipment

2.18.1 Every heating or cooking appliance is to be controlled as a complete unit by a multi-pole linked switch mounted in the vicinity of the appliance.

2.18.2 In the case of small heaters, for individual cabins or similar small dry accommodation spaces where the floor coverings, bulkheads and ceiling linings are of insulating materials, a single pole switch is acceptable.

2.18.3 Heating arrangements of the exposed element type are not to be used in any location.

2.18.4 Means of cutting off power to the galley except lighting circuits, in the event of a fire, are to be provided outside the galley exits, at positions which will not readily be rendered inaccessible by such a fire.

2.19 Temporary external supply/shore connection

2.19.1 Where arrangements are provided for the supply of electric power from a source on shore or elsewhere, a connection box is to be installed in an easily accessible location in a manner suitable for the convenient reception of flexible cables from the external source. This box should contain a circuit-breaker or isolating switch and fuses and terminals of ample size and suitable shape to facilitate a satisfactory connection. The mechanical stress of the portable cable is to be conveyed directly to the metallic framework and not to electrical connectors. Suitable cables, permanently fixed, are to be provided, connecting the circuit breaker/isolating switch in the connection box to a linked switch and/or circuit breaker at the main switchboard.

2.19.2 For alternating current systems an earthed terminal is to be provided for the reception of three-phase external supplies with earthed neutrals.

2.19.3 The external connection is to be provided with an indicator at the main switchboard in order to show when the cable is energized.

2.19.4 Means are to be provided for checking the polarity (for direct current) or the phase sequence (for three-phase alternating current) of the incoming supply. This device should be connected between the incoming connectors and the interrupting device in the connection box.

2.19.5 A notice is to be provided at the connection box giving complete information on the system of supply and the normal voltage (and frequency for alternating current) of the ship's installed system. Full details of the procedure for effecting the connection are to be given on this notice.

2.19.6 Alternate arrangements for providing a temporary external supply will be specially considered.

2.20 Permanent external supply

2.20.1 Details are to be submitted for consideration in each specific case.

2.21 Protection

2.21.1 General

2.21.1.1 All installations are to be protected against accidental over-currents including short circuits and other electrical faults. The choice, location and characteristics of the protective device are to provide complete and co-ordinated protection to ensure:

a) Elimination of the fault to reduce damage to the system and hazard of fire.

b) Continuity of service so as to maintain, through the discriminative action of the protective devices, the supply to essential and all other services not directly affected by the fault.

2.21.2 Protection against overload

2.21.2.1 Protection against overloads may be provided by circuit-breakers, automatic switches or fuses. The tripping characteristics of these devices are to be appropriate to the system. Fuses rated above 320 A are not to be used for protection against overload, but may be used for short-circuit protection.

2.21.2.2 The rating or appropriate setting of the overload protective device for each circuit should be permanently indicated at the location of the protective device.

2.21.2.3 The overload releases of circuit-breakers for generators and the setting of preferential trip relays are to be adjustable or, if of the non-adjustable type, are to be readily replaceable by others of different values.

2.21.3 Protection against short-circuit

2.21.3.1 Protection against short-circuit currents is to be provided by circuit-breakers or fuses.

2.21.3.2 The breaking capacity of every protective device is to be not less than the maximum value of the short-circuit current which can flow at the point of installation at the instant of contact separation.

2.21.3.3 The making capacity of every circuit-breaker or switch intended to be capable of being closed, if necessary, on short circuit, is to be not less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

2.21.3.4 Every protective device or contactor not intended for short circuit interruption is to be adequate for the maximum short-circuit current which can occur at the point of installation having regard to the time required for the short circuit to be removed.

2.21.3.5 In the absence of precise data of rotating machines the following short-circuit currents at the machine terminals are to be assumed. The short circuit current is to be the sum of short circuit currents of generators and that of motors;

a) Direct current systems

- Ten times full load current for generators normally connected (including spare),

- Six times full load current for motors simultaneously in service;

b) Alternating current systems.

- Ten times full load current for generators normally connected (including spare) - symmetrical RMS,

- Three times full load current for motors simultaneously in service.

2.21.4 Combined circuit-breakers and fuses

2.21.4.1 The use of a circuit-breaker of breaking capacity less than the prospective short-circuit current at the point of installation is permitted, provided that it is preceded on the generator side by fuses, or by a circuit-breaker having at least the necessary breaking capacity. The generator breakers are not to be used for this purpose.

2.21.4.2 Fused circuit-breakers with fuses connected to the load side may be used where operation of the circuit-breaker and fuses is co-ordinated.

2.21.4.3 The characteristics of the arrangement are to be such that:

a) When the short-circuit current is broken, the circuit-breaker on the load side is not to be damaged and is to be capable of further service,

b) When the circuit-breaker is closed on the short-circuit current, the remainder of the installation is not to be damaged. However, it is admissible that the circuit-breaker on the load side may require servicing after the fault has been cleared.

2.21.5 Protection of circuits

2.21.5.1 Short circuit protection is to be provided in each live pole of a direct current system and in each phase of an alternating current system.

2.21.5.2 Protection against overloads is to be provided as follows:

a) Two-wire direct current or single-phase alternating current system - at least one line or phase,

b) Insulated three-phase alternating current system - at least two phases,

c) Earthed three-phase alternating current system - all three phases.

2.21.5.3 No fuse, non-linked switch or non-linked circuit-breaker is to be inserted in an earthed conductor. Any switch or circuit-breaker fitted is to operate simultaneously in the earthed conductor and the insulated conductors.

2.21.5.4 These requirements do not preclude the provision (for test purposes) of an isolating link to be used only when the other conductors are isolated.

2.21.6 Protection of generators

2.21.6.1 In addition to over-current protection, the provisions of 2.21.6.2 to 2.21.6.7 are to be adhered to as a minimum.

2.21.6.2 For generators not arranged to run in parallel :

- A multi-pole circuit-breaker arranged to open simultaneously all insulated poles or in the case of generators rated at less than 50 [kW] a multi-pole linked switch with a fuse in each insulated pole on the generator side. The fuse rating in such cases is to be maximum 125 per cent of the generator rated current.

2.21.6.3 For generators arranged to run in parallel:

- A circuit-breaker arranged to open simultaneously all insulated poles. This circuit-breaker is to be provided with :

a) For direct current generators, instantaneous reverse-current protection operating at not more than 15 percent rated current,

b) For alternating current generators :

i) A reverse-power protection, in accordance with characteristics of prime movers is to be set as shown in Table 2.21.6.3

Table 2.21.6.3 Reverse power protection

Prime Mover	Protection setting (as % of full load of generator)	Time delay
Diesel Generator	Between 2 to15%	Between 3 to 10 sec
Turbo Generator	Between 2 to 6 %	

ii) A device for protection against the effects of parallel connection in opposite phase.

2.21.6.4 The reverse-current protection is to be adequate to deal with the reverse-current conditions emanating from the network, e.g. from winches, the reverse-power protection specified for alternating current generators may be replaced by other devices ensuring adequate protection of the prime movers.

2.21.6.5 A fall of 50 per cent in the applied voltage should not render the reverse-current mechanism inoperative, although it may alter the amount of reverse-current required to open the breaker.

2.21.6.6 The following protective gear is also to be provided for direct current generators arranged to operate in parallel :

a) Where an equaliser connection is in use the reverse-current protection is to be provided in the pole opposite to that in which the series winding is connected,

b) For compound generators an equaliser switch for each generator so interlocked that it closes before and opens after the main contacts of the circuit-breaker with which it is associated, or a three-pole circuit-breaker with all poles acting simultaneously.

2.21.6.7 Generator circuit-breakers are normally to be provided with under voltage release.

2.21.7 Protection of essential services

2.21.7.1 Where generators are operated in parallel and essential services are electrically operated, arrangements are to be made to disconnect automatically the excess non-essential load when the generators are overloaded.

2.21.7.2 If required, this load shedding may be carried out in one or more stages according to the overload ability of the generating sets, taking into consideration the relative importance of the loads being thus disconnected.

2.21.7.3 In cargo ships, circuits for cargo refrigeration machinery are to be included in the last group of services to be disconnected.

2.21.8 Protection of feeder circuits

2.21.8.1 Isolation and protection of each main distribution circuit is to be ensured by a multi-pole circuit-breaker, multi-pole fused circuit-breakers or multi-pole switch and fuses. The provisions of 2.21.2, 2.21.3 and 2.21.5 are to be complied with. The protective devices are to allow excess current to pass during the normal accelerating period of motors. Where multi-pole switch and fuses are used, the fuses are generally to be installed between the busbars and the switch.

2.21.8.2 Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

2.21.8.3 Motors of rating exceeding 0.5 [kW] and all motors for essential services are to be protected individually against overload and short- circuit. The short-circuit protection can be provided by the same protective device for the motor and its supply cable. For essential motors which are duplicated, the overload protection may be replaced by an overload alarm, if desired.

2.21.8.4 For motors intended to provide uninterrupted service the protective gear is to have a delay characteristic to enable the motor to start, and to operate on overload before the windings reach an un-acceptably high temperature. The current which the protective device will allow to pass indefinitely is not to exceed 125 per cent of the rated current.

2.21.8.5 For motors for intermittent service the current setting and the delay are to be chosen in relation to the load factor of the motor.

2.21.8.6 Where fuses are used to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overloads in the case of single phasing.

2.21.9 Protection of power transformers

2.21.9.1 The primary circuits of power transformers are to be protected against short-circuit by circuit-breakers or fuses. The rating of fuses or the setting for overcurrent releases of circuit breakers is not to exceed 125 per cent of rated primary current.

2.21.9.2 Each of the secondary circuits is to be provided with a multiple isolating switch as shown in Fig.2.21.9.2.

2.21.9.3 When transformers are arranged to operate in parallel, an automatic protective device is to be provided on the secondary circuits. Switches and circuit-breakers are to be capable of withstanding surge currents.

2.21.10 Protection of lighting circuits

2.21.10.1 Lighting circuits are to be provided with overload and short- circuit protection.

2.21.11 Protection of meters, pilot lamps, capacitors, control transformers and control circuits

2.21.11.1 Short circuit protection is to be provided for voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps, control transformers and control circuits together with their connecting leads by means of protective devices fitted to each insulated pole or phase.

2.21.11.2 A pilot lamp installed as an integral part of another item of equipment need not be individually protected, provided it is fitted in the same enclosure. Where a fault in a pilot lamp would jeopardise the supply to essential equipment such lamps are to be individually protected.

2.21.11.3 Where capacitors for suppression of radio interference are fitted to busbars, generators or steering gear, fuses of appropriate size are to be connected in the capacitor circuit.

2.21.12 Protection of batteries

2.21.12.1 Accumulator batteries other than engine starting batteries are to be protected against overload and short circuit by devices, in each insulated pole, placed at a position adjacent to the battery compartment.

2.21.13 Protection of communication circuits

2.21.13.1 Communication circuits other than those supplied from primary batteries are to be protected against overload and short-circuit.

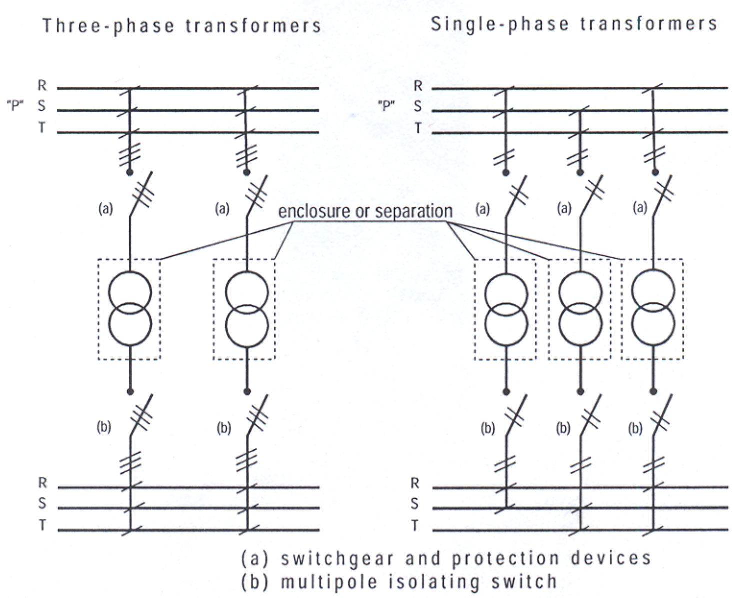


Fig.2.21.9.2

Section 3

Cables and Busbar Trunking Systems

3.1 General

3.1.1 The requirements of this Section are applicable to fixed cables on permanent installations. For flexible cables, the requirements apply only as far as applicable.

3.1.2 Cables are to be of a type approved by IRS.

3.1.3 Electric cables for fixed wiring are to be designed, manufactured and tested in accordance with the relevant IEC Publication stated in Table 3.1.1 or an acceptable relevant standard.

3.1.4 The use of flexible cables on permanent installations is to be limited to applications where flexibility is necessary, and the lengths of such flexible cables are to be kept as short as practicable. Additional requirements may be specified for flexible cable, depending on the applications.

Table 3.1.1 : Electric cables

Application	IEC Publication
General constructional and testing requirements	60092-350
Fixed power and control circuits	60092-353
Instrumentation, control and communication circuits up to 60 V	60092-375
Control circuits up to 250 V	60092-376
Fixed high voltage power circuits	60092-354
Mineral insulated	60702

3.1.5 Electric cables complying with IEC Publication 60502 are to have stranded conductors.

3.2 Conductors

3.2.1 High conductivity annealed copper only is to be used.

3.2.2 Where the conductor insulation is composed of vulcanised rubber or of a synthetic rubber liable to contain sulphides, the copper wires are to be tinned or alloy coated and the surface is to be bright. Similarly the copper wires are to be tinned or alloy coated when the insulation is composed of a cambric impregnated with a product other than bitumen, unless an efficient separator is inserted between conductor and insulation.

3.2.3 Conductor composition and stranding is to be selected so that adequate flexibility of the finished cable is assured. Conductors of nominal cross-section 2.5 [mm^2] and less need not be stranded. This requirement does not apply to mineral-insulated cables which have solid conductors.

3.2.4 Cores of multi-core cables are to be readily identifiable.

3.3 Insulating materials

3.3.1 Permitted insulating materials with maximum rated conductor temperatures are given in Table 3.3.1.

3.3.2 Where a rubber or rubber-like material with maximum conductor temperature greater than 60°C is used, it is to be readily identifiable.

3.3.3 Consideration will be given to other insulating materials.

Table 3.3.1 : Insulating materials & maximum rated conductor temperature	
Type of insulating compound	**Maximum rated conductor temp. °C**
Thermoplastics	
Based upon polyvinyl chloride or co-polymer of vinyl chloride and vinyl acetate	60
Based upon polyethylene	60
Elastomeric or thermosettings	
Based upon ethylene propylene rubber or similar (EPM or EPDM)	85
Based upon chemically crosslinked polyethylene	85
Based upon silicon rubber	95
Mineral	95

3.4 Construction

3.4.1 Electric cables are to be at least of a flame-retardant type. Compliance with IEC Publication 60332-1: Tests on a single vertical insulated cable or a test procedure equivalent thereto, will be acceptable.

3.4.2 Exemption from the requirements of 3.4.1 for applications such as radio frequency or digital communication systems, which require the use of particular types of cable, will be subject to special consideration.

3.4.3 Where electric cables are required to be of a 'fire resistant type', they are to comply with the requirements of IEC 60331-31 for cables of greater than 20 [mm] overall diameter, otherwise 60331-21.

Notes:

a) Installation methods specified in 3.11 are to be applied.

b) Cables complying with alternative national standards and suitable for use in a marine environment may be considered.

c) Fire resistant type cables are to be easily distinguishable, for e.g. by way of colour code.

d) Following standards may be used for special cables such as electrical data and optical fibre cables:

IEC60331-23 : Electric data cables
IEC60331-25 : Optical fiber cables.

3.4.4 Where electric cables are installed in locations exposed to the weather, in damp and in wet situations, in machinery compartments, refrigerated spaces or exposed to harmful vaporous including oil vapour they are to have the conductor insulating materials enclosed in an impervious sheath of material appropriate to the expected ambient conditions.

3.4.5 Electric cables where it is required that their construction includes metallic sheaths, armouring or braids are to be provided with an overall impervious sheath or other means to protect the metallic elements against corrosion.

3.4.6 Where single core electric cables are used in circuits rated in excess of 20 A and are armoured the armour is to be of a non-magnetic material.

3.4.7 Electric cables are to be constructed such that they are capable of withstanding the mechanical and thermal effects of the maximum short circuit current which can flow in any part of the circuit in which they are installed, taking into consideration not only the time/current characteristics of the circuit protective device but also the peak value of the prospective short circuit current. Where electric cables are to be used in circuits with a maximum short circuit current in excess of 70 kA, evidence is to be submitted for consideration when required demonstrating that the cable construction can withstand the effects of the short circuit current.

3.4.8 All high voltage electric cables are to be readily identified by suitable marking.

3.5 Testing

3.5.1 Routine tests are to include at least

- measurement of electrical resistance of conductors;

- high voltage test;

- insulation resistance measurement; and

- partial discharge tests in case of high voltage cables.

Evidence of successful completion of routine tests is to be provided by the manufacturer.

3.5.2 Particular, special and type tests are to be made, when required, in accordance with the requirements of relevant publication or national standard.

3.6 Voltage rating

3.6.1 The rated voltage of any cable is not to be lower than the nominal voltage of the circuit for which it is used. Cables exposed to voltage surges associated with highly inductive circuits, e.g. contactor operating circuits for winches etc., are to be given special consideration.

3.6.2 Electric cables used in unearthed systems are to be suitably rated to withstand the additional stresses imposed on the insulation due to an earth fault.

3.7 Choice of insulating material

3.7.1 The rated operating temperature of the insulating material is to be at least 10°C higher than the maximum ambient temperature liable to be produced in the space where the cable is installed.

3.8 Choice of protective covering

3.8.1 Cables fitted in the following locations are to have an impervious sheath. In permanently wet situations, metallic sheaths are to be used for cables with hydroscopic insulation.

- Decks exposed to weather;

- Bathrooms;

- Refrigerated spaces;

- Machinery spaces; and

- Any other location where water condensation or harmful vapour (e.g. oil vapour) may be present.

3.8.2 All cables are to be of flame-retardant type or fire-resisting type, except that non flame-retardant cables may be accepted for final circuits only in the following cases :

a) Where cables are installed in metallic conduits having internal diameter not exceeding 25 [mm] and provided the conduits are electrically and mechanically continuous.

b) Bare lead sheathed cable having conductor sections not exceeding 4.5 [mm^2].

3.9 Current rating

3.9.1 The highest continuous load carried by a cable is not to exceed its current rating. The diversity factor of the individual loads and the duration of the maximum demand may be allowed for in estimating the maximum continuous load and is to be shown on the plans submitted for approval.

3.9.2 The cross sectional area of the conductors is to be sufficient to ensure that, under short circuit conditions, the maximum rated conductor temperature for short circuit operation is not exceeded, taking in to account the time current characteristics of the circuit protective device and the peak value of the prospective short circuit current.

3.9.3 In assessing the current rating of lighting circuits, every lampholder is to be assessed at the maximum load likely to be connected to it, with a minimum of 60 W, unless the fitting is so connected as to take only a lamp rated at less than 60 W.

3.9.4 Cables supplying winches, cranes, windlasses and capstans are to be suitably rated for their duty. Unless the duty is such as to require a longer time rating, cables for winch or crane motors may be half hour rated on the basis of the half hour [kW] rating of the motors. Cables for windlass and capstan motors are to be not less than one hour rated on the basis of the one hour [kW] rating of the motor. In all cases the rating is to be subject to the voltage drop being within the specified limits.

3.9.5 The current ratings given in Table 3.9.1 are based on the maximum operating conductor temperatures, given in Table 3.3.1. Where a more precise evaluation of current rating has been carried out based on experimental or calculated data, details may be submitted for approval.

Table 3.9.1 : Electric cable current rating, normal operation, based on ambient temp. of 45°C

Nominal cross-section in [mm²]	Continuous current rating in amperes (based on ambient temp. 45°C)								
	Thermoplastic, PVC, PE			EP rubber and cross linked PE			Silicon rubber or mineral		
	Single core	2 core	3 or 4 core	Single core	2 core	3 or 4 core	Single core	2 core	3 or 4 core
1	8	7	6	16	14	11	20	17	14
1.5	12	10	8	20	17	14	24	20	17
2.5	17	14	12	28	24	20	32	27	22
4	22	19	15	38	32	27	42	36	29
6	29	25	20	48	41	34	55	47	39
10	40	34	28	67	57	47	75	64	53
16	54	46	38	90	77	63	100	85	70
25	71	60	50	120	102	84	135	115	95
35	87	74	61	145	123	102	165	140	116
50	105	89	74	180	153	126	200	175	140
70	135	115	95	225	191	158	255	217	179
95	165	140	116	275	234	193	310	264	217
120	190	162	133	320	272	224	360	306	252
150	220	187	154	365	310	256	410	349	287
185	250	213	175	415	353	291	470	400	329
240	290	247	203	490	417	343	570	485	400
300	335	285	235	560	476	392	660	560	460

3.10 Correction factors for current rating

3.10.1 Bunching of cables : Where more than six cables belonging to the same circuit are bunched together a correction factor of 0.85 is to be applied.

3.10.2 Ambient temperature : The current ratings in Table 3.9.1 are based on an ambient temperature of 45°C. For other values of ambient temperature the correction factors shown in Table 3.10.1 are to be applied.

3.10.3 Intermittent Service : Where the load is intermittent, the correction factors in Table 3.10.2 may be applied for half hour and one hour ratings. In no case is a shorter rating than one half hour rating to be used, whatever the degree of intermittency.

Table 3.10.1 : Correction factors for temperature

Insulation material	Correction factor for ambient air temperature of °C										
	35	40	45	50	55	60	65	70	75	80	85
PVC, Polyethelene	1.29	1.15	1.00	0.82	-	-	-	-	-	-	-
EPR, XLPE	1.12	1.06	1.00	0.94	0.87	0.79	0.71	0.61	0.5	-	-
Mineral, Silicon rubber	1.10	1.05	1.00	0.95	0.89	0.84	0.77	0.63	0.55	0.45	-

Table 3.10.2 : Correction factors for intermittent rating

Correction factor	Half-hour rating		One-hour rating	
	With metallic sheath [mm^2]	Without metallic sheath [mm^2]	With metallic sheath [mm^2]	Without metallic sheath [mm^2]
1.00	Upto 20	Upto 75	upto 67	upto 230
1.10	21 - 40	76 - 125	68 - 170	231 - 400
1.15	41 - 65	126 - 180	171 - 290	401 - 600
1.20	66 - 95	181 - 250	291 - 430	-
1.25	96 - 130	251 - 320	431 - 600	-
1.30	131 - 170	321 - 400	-	-
1.35	171 - 220	401 - 500	-	-
1.40	221 - 270	-	-	-

3.11 Installation of cables

3.11.1 Cable runs are to be, as far as practicable, straight and accessible and as high as possible above bilges.

3.11.2 The installation of cables across expansion joints in any structure is to be avoided. Where such installation is unavoidable, a loop of cable of length proportional to the expansion of the joint is to be provided. The internal radius of the loop is to be at least twelve times the external diameter of the cable.

3.11.3 Where a duplicate supply is required and provided for any particular service, the two cables are to follow different routes which are separated throughout their length as widely as is practicable, to minimise the probability of simultaneous damage to the two circuits. The provision is also applicable to control circuits.

3.11.4 Generator cables are as far as practicable to be divided between two or more cable runs. These cable runs are to be separated as far apart as practicable.

3.11.5 Cables supplying essential or important consumers are generally not to be installed in rooms where there is an excessive fire hazard such as paint stores, galleys, etc. purifiers, welding-gas bottles etc.

3.11.6 Cables having insulating materials with different maximum-rated conductor temperatures are not to be bunched together, or, where this is not practicable, the cables are to be operated so that no cable reaches temperature higher than that permitted for the lowest temperature-rated cable in the group.

3.11.7 Cables having a protective covering which may damage the covering of other cables are not to be bunched with those of other cables.

3.11.8 The minimum internal radius of cable bends, which are not subjected to movements by expansion when installed, is to be generally in accordance with Table 3.11.1.

3.11.9 Electric cables are not to be coated or painted with materials which may adversely affect their sheath or their fire protection.

3.11.10 Where electric cables are installed in refrigerated spaces they are not to be covered with thermal insulation but may be placed directly on the face of the refrigeration chamber, provided that precautions are taken to prevent the electric cables being used as casual means of suspension.

3.11.11 Cable runs are normally not to include joints. However, if a joint is necessary it is to be carried out with prior approval and with due consideration to methods of splicing that retain the original mechanical and electrical properties of the cable and which ensure that all conductors are adequately secured, insulated and protected from atmospheric action. Terminals and busbars are to be of dimensions adequate for the cable rating.

3.11.12 Where electric cables are installed in bunches, provision is to be made to limit the propagation of fire, which may be achieved by either of the following:

a) Cables which have been tested in accordance with IEC 60332-3 Category A or a test procedure for cables installed in bunches equivalent thereto.

b) (Refer to Fig.3.11.12a, b, c and d)

i) Fire stops having at least B0 penetrations fitted as follows:

- Cable entries at the main and emergency switchboard,
- Where cable enter engine control rooms,
- Cable entries at centralized control panels for propulsion machinery and essential auxiliaries,
- At each end of totally enclosed cable trunks, and

ii) In enclosed and semi enclosed spaces, cable runs are to comply with the following:

- to have fire protection coating applied
- to at least 1 metre in every 14 metres
- to entire length of vertical runs or
- Fitted with fire stops having at least B0 penetrations every second deck or approximately 6 metres for vertical runs and at every 14 metres for horizontal runs.

Table 3.11.1 : Minimum internal radii of bends in cables for fixed wiring

Cable construction		Overall diameter of cable	Minimum internal radius of bend (times overall diameter of cable)
Insulation	**Outer covering**		
Thermoplastic and elastomeric 600/1000 V and below	Metal sheathed Armoured and braided	Any	6D
	Other finishes	≤ 25 [mm] > 25 [mm]	4D 6D
Mineral	Hard metal sheathed	Any	6D
Thermoplastic and elastomeric above 600/1000 V			
- single core	Any	Any	20D
- multicore	Any	Any	15D

3.12 Mechanical protection of cables

3.12.1 Cables exposed to risk of mechanical damage are to be protected by metal channels or casing or enclosed in steel conduit unless the protective covering (e.g. armour or sheath) is adequate to withstand the possible damage.

3.12.2 Cables, in spaces where there is exceptional risk of mechanical damage (e.g. on weather decks, in cargo hold areas and inside the cargo holds) and also below the floor in engine and boiler rooms, are to be suitably protected, even if armoured, unless the steel structure affords adequate protection.

3.12.3 Metal casings for mechanical protection of cables are to be efficiently protected against corrosion.

3.12.4 Non metallic protective casings and fixings are to be flame retardant in accordance with the requirements of IEC Publication 92-101.

3.12.5 If cable trays/protective casings are made of plastics materials, then they are to comply with the requirements in 3.12.5.1 to 3.12.5.4.

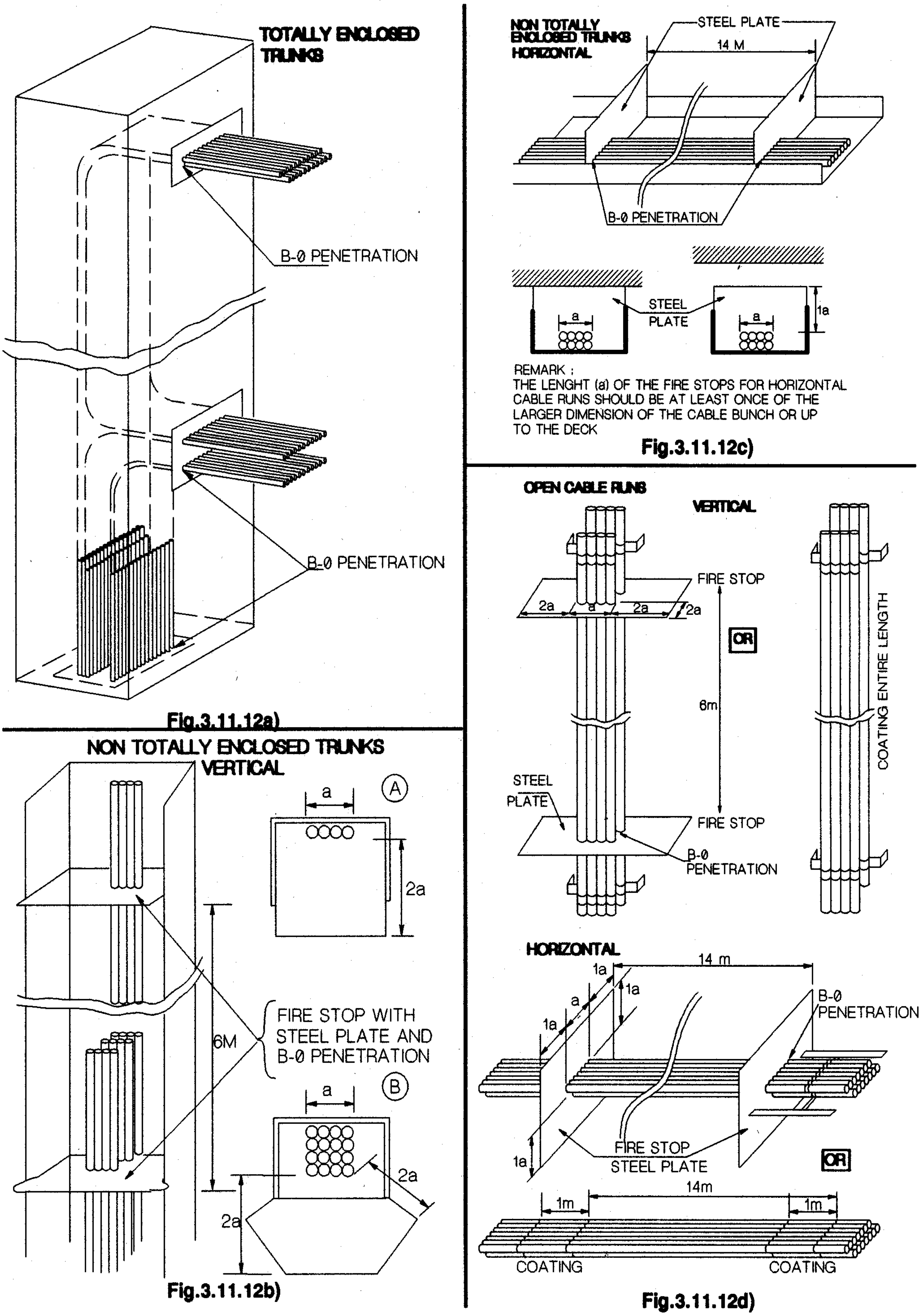
3.12.5.1 They are to be of approved type and are to be supplemented by metallic fixing and straps such that in the event of a fire they, and the cables affixed, are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route. The spacing of their metallic fixing and straps is generally not to exceed 2.0 m.

3.12.5.2 When used on open deck, they are additionally to be protected against ultra-violet light.

3.12.5.3 The load on the plastics cable trays/protective casings is to be within the Safe Working Load (SWL) and the spacing of support, in general, is not to exceed 2 metres.

3.12.5.4 The sum of the total cross-sectional area of the cables, based on their external diameter, is not to exceed 40% of the internal cross-sectional area of the protective casing. This does not apply to a single cable in a protective casing.

Note : Cable trays/protective casings made of plastic materials are to be approved in accordance with the Classification Notes issued by IRS.



Note : (All fire stops steel plates 3 mm thk)

Fig.3.11.12a) to d) : Installation of cables

3.13 Earthing of metal coverings

3.13.1 Metal coverings of cables are to be effectively earthed at both ends of the cable, except its final sub-circuits, other than those installed in hazardous zones or spaces, earthing at the supply end only will be considered adequate. This does not necessarily apply to instrumentation cables where single point earthing may be desirable for technical reasons.

3.13.2 The electrical continuity of all metal coverings of cables throughout the length of the cable, particularly at joints and tappings, is to be ensured.

3.13.3 The lead sheath of lead-sheathed cables is not to be used as the sole means of earthing the non-current carrying parts of items of equipment.

3.14 Securing of cables

3.14.1 Cables, other than those attached to portable appliances and those installed in pipes, conduits or special casing are to be effectively supported and secured in a manner that prevents damage to their coverings.

3.14.2 Supports and accessories are to be robust and are to be of corrosion-resistant material or suitably corrosion inhibited before erection.

3.14.3 The distance between supports, for horizontal as well as vertical runs of cables, is to be chosen according to the type/size of cable, but generally in accordance with Table 3.14.1.

3.14.4 When electric cables are fixed by means of clips or straps manufactured from a material other than metal the material is to be flame retardant and the fixings are to be supplemented by suitable metal clips or straps at regular intervals, each not exceeding 2 [m].

3.14.5 Single core cables are to be firmly fixed, using supports of strength adequate to withstand forces corresponding to the values of the peak prospective short circuit current.

Table 3.14.1 : Distance between supports

External diameter of cable			
Exceeding [mm]	**Not exceeding [mm]**	**Non-armoured cables [mm]**	**Armoured cables [mm]**
-	8	200	250
8	13	250	300
13	20	300	350
20	30	350	400
30	-	400	450

3.15 Penetration of bulkheads and decks by cables

3.15.1 Penetration of watertight bulkheads or decks is to be carried out with either individual watertight glands or with packed watertight boxes carrying several cables. In either case, the watertight integrity and strength of the bulkheads and decks are to be maintained. Where cables with polyvinyl chloride insulation are being installed, particular care is to be taken to avoid damage to the sheathing during the fitting of watertight bulkhead glands.

3.15.2 Where fire-resisting or fire-retarding bulkheads or decks are drilled for the passage of cables, all arrangements are to be such that this fire resisting or fire retarding property and strength are not diminished.

3.15.3 Where cables pass through gastight bulkheads or decks separating hazardous zones or spaces, arrangements are to be such that the gastight integrity and strength of the bulkhead or deck are not impaired.

3.15.4 Where cables pass through non-watertight bulkheads or structural steel, the holes are to be bushed, in order to protect the cables, with lead or other approved material which will prevent damage to the cables by abrasion. If the steel is 6 [mm] thick, adequately rounded edges may be accepted as the equivalent of bushing.

3.15.5 Cables passing through decks are to be protected by deck tubes or ducts.

3.15.6 Materials used for glands and bushings are to be such that there is no risk of corrosion.

3.15.7 Where rectangular holes are cut in bulkheads or structural steel the corners are to be adequately rounded.

3.15.8 The distance from cable penetrations to flanges of steam pipes or hot oil pipes is to be not less than 500 [mm].

3.16 Installation of cables in pipes and conduits

3.16.1 Installation of cables in pipes and conduits is to be carried out in such a manner that there is no damage to the cable covering.

3.16.2 Metal conduit systems are to be earthed and are to be mechanically and electrically continuous across joints. Individual short lengths of conduit need not be earthed.

3.16.3 The internal radius of bend of pipes and conduit is to be not less than that laid down for cables, provided that for pipes exceeding 64 [mm] diameter the internal radius of bend is not less than twice the diameter of the pipe.

3.16.4 The drawing-in factor (ratio of the sum of the cross-sectional areas of the cables, based on their external diameter, to the internal cross-section area of the pipe) is not to exceed 0.4.

3.16.5 Expansion joints are to be provided where necessary.

3.16.6 Cable pipes and conduits are to be adequately and effectively protected against corrosion. Where necessary, openings are to be provided at the highest and lowest points to permit air circulation and to prevent accumulation of water.

3.16.7 Cable pipes are to be effectively supported, particularly in areas where they are likely to be subject to heavy vibrations.

3.16.8 Cables in a conduit should belong to the same temperature class.

3.16.9 Where cables are laid in trunks, the trunks are to be so constructed as not to afford passage for fire from one deck or compartment to another.

3.16.10 Cables used for cold cathode luminous discharge lamps are not to be installed in metal conduit unless protected by metal sheath or screen.

3.16.11 Non-metallic ducting or conduit is to be of flame-retardant material. PVC conduit is not to be used in refrigerated spaces or on open decks, unless specially approved.

3.17 Installation of cables in refrigerated spaces

3.17.1 The installation of cables in refrigerated spaces is to be avoided as far as possible.

3.17.2 PVC insulated cables are not to be installed in refrigerated spaces.

3.17.3 Cables installed in refrigerated spaces are to have a watertight or impervious sheath and are to be protected against mechanical damage. If an armoured cable is used, the armour, unless galvanised or of non-corrosive material, is to be protected against corrosion by an additional moisture-resisting covering.

3.17.4 Cables are not to be embedded in or covered by the thermal insulation. They may be fixed to galvanised perforated plates with a space left between the back of the plate and the wall of the room.

3.17.5 Where cables entering a refrigerated space have to pass through the thermal insulation, they are to be installed at right angle to such insulation and are to be protected by a pipe, sealed at each end. Alternatively, the cables may be passed through solid door frames, the necessary holes being sealed at each end.

3.17.6 Precautions are to be taken to prevent the placing of hooks around the cable as a casual means of suspension.

3.17.7 Supporting strips, plating or hangers used for securing the cables are to be galvanised or otherwise protected against corrosion.

3.18 Cables for alternating current

3.18.1 Generally, multi-core cables are to be used in A.C. installations. Where it is necessary to use single-core cables for alternating current circuits rated in excess of 20 A the requirements of 3.18.2 to 3.18.9 are to be complied with.

3.18.2 Cables are to be either non-armoured or armoured with non- magnetic material.

3.18.3 If installed in pipe or conduit, cables belonging to the same circuit are to be installed in the same conduit, unless the conduit or pipe is of non-magnetic material.

3.18.4 Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.

3.18.5 When installing two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits or three-phase and neutral circuits, the cables are to be in contact with one another, as far as possible. In any case, the distance between the external covering of two adjacent cables is not to be greater than one diameter.

3.18.6 In the case of circuits using two or more parallel connected cables per phase, all cables are to have the same length and cross sectional area.

3.18.7 Where single core cables of rating exceeding 50 A and over 30 [m] in length are used, the phases are to be transposed at regular intervals of approximately 15 [m] in order to obtain the same degree of impedance of circuits.

3.18.8 Where single core cables of rating exceeding 50 A are used, magnetic material is not to be placed between single-core cables of a group. If these cables pass through steel plates, all cables of the same circuit are to pass through the plate or gland so constructed that there is no magnetic material between the cables, and suitable clearance is provided between the cable core and magnetic material. This clearance, wherever practicable, is not to be less than 75 [mm] when the current exceeds 300 A. For currents between 50 A and 300 A the clearance may be proportionately reduced.

3.18.9 If single-core cables of current rating greater than 250 A are run along a steel bulkhead, wherever practicable the cables should be spaced away from the steel.

3.19 Cable ends

3.19.1 The ends of all conductors of cross-sectional area greater than 4 [mm^2] are to be fitted with soldering sockets, compression type sockets or mechanical clamps. Corrosive fluxes are not to be used.

3.19.2 Cables having hygroscopic insulation (e.g. mineral insulated) are to have their ends sealed against ingress of moisture.

3.19.3 Cables with a supplementary insulating belt beneath the protective sheath are to have additional insulation at those points where the insulation of each core makes or may make contact with earthed metal.

3.20 Busbar trunking systems

3.20.1 Where busbar trunking systems are used in place of electric cables, they are to comply with the requirements of 3.20.2 to 3.20.6, in addition to the applicable requirements in Section 3.

3.20.2 The busbar trunking, or enclosure system, is to have a minimum ingress protection of IP54, according to IEC 60529 Degrees of protection provided by enclosures (IP Code).

3.20.3 The internal and external arrangements of the busbar trunking or enclosure system are to ensure that the fire and/or watertight integrity of any structure through which it passes is not impaired.

3.20.4 Where the busbar trunking system is employed for circuits on and below the bulkhead deck, arrangements are to be made to ensure that circuits on other decks are not affected in the event of partial flooding under the normal angles of inclination given in Chapter 1, Table 1.7.1.

3.20.5 Supports and accessories are to be robust and are to be of corrosion-resistant material or suitably corrosion inhibited before erection. The support system is to effectively secure the busbar trunking system to the ship's structure.

3.20.6 When accessories are fixed to the busbar system by means of clips or straps manufactured from a material other than metal, the fixings are to be supplemented by suitable metal clips or straps, such that, in the event of a fire or failure, the accessories are prevented from failing and causing injury to personnel and/or an obstruction to any escape route. Alternatively, the busbar system may be routed away from such areas.

Section 4

Switchgear and Control Gear Assemblies

4.1 Main and emergency switchboards

4.1.1 Location and installation

4.1.1.1 Switchboards are to be installed in accessible and well ventilated dry spaces free from flammable gases and acid fumes.

4.1.1.2 Switchboards are to be secured to a solid foundation and protected against shocks and damage due to leaks and falling objects. They are to be self-supported, or be braced to the bulkhead or the deck above. In case the latter method is used, the means of bracing is to allow normal deflections of the deck without buckling the control cell or assembly structure.

4.1.1.3 Pipes should not be installed directly above or in front of or behind switchboards. If such piping is unavoidable, suitable protection is to be provided in these positions.

4.1.1.4 An adequate, unobstructed working space is to be left in front of switchboards. At the rear, a clearance of at least 0.6 m is to be maintained except that this may be reduced to 0.5 m in way of stiffeners or frames. If switchboards are enclosed at the rear and are fully serviceable from the front, clearance at the rear will not be required unless necessary for cooling.

4.1.1.5 The main switchboard is to be so placed relative to one main generating station that, as far as practicable, the integrity of the normal electrical supply may be affected only by a fire or other casualty in one space. The main switchboard is to be located as close as practicable to the main generating station, within the same machinery space and the same vertical and horizontal A60 fire boundaries. An environmental enclosure for main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the space, is not to be considered as separating the switchboards from the generators.

4.1.1.6 Where essential services for steering and propulsion are supplied from section boards these and any transformers, converters and similar appliances constituting an essential part of electrical supply system are also to satisfy 4.1.1.5.

4.1.2 Construction of switchboards

4.1.2.1 Switchboards are to have roof with degree of protection IP 22 and are to be of dead front type.

On systems with voltages above 50 V up to and including 1000 V, front and rear dead type switchboards are to be used.

4.1.2.2 All main switchboards are to be guarded by hand rails either made of hardwood or insulated. Where access is provided behind a main switchboard, the handrails on the rear are to be horizontal, and so placed that one cannot accidentally fall into the switchboard. Further, insulated mats or gratings are to be laid on the floor of passage-ways in front of and to the rear of switchboards. Instruments and handles or push buttons for switchgear are to be placed on the front of the switchboard (except for isolating switches, if used). All other parts which require operation, are to be accessible and so placed that the risk of accidental touching of current carrying parts, or accidental making of short-circuits and earthings, is reduced as far as practicable.

4.1.2.3 Section boards (sub-switchboards) and distribution boards are to be enclosed unless they are installed in a cupboard or compartment to which only authorised personnel have access, in which case the cupboard may serve as an enclosure.

4.1.2.4 Framework, panels and doors of switchboards are generally to be of steel or aluminium alloy, and are to be of rigid construction.

4.1.2.5 All parts of the main switchboard are to be accessible for maintenance work.

4.1.2.6 Equipment for each generator and for different distribution systems are to be placed in separate cubicles (panels) or are to be separated from each other by partitions clearly marked with the actual voltages.

4.1.2.7 Doors, behind which equipment requiring operation is placed, are to be hinged. Arrangement is also to be provided to keep the hinged doors open.

4.1.2.8 Cable entrances are generally to be from below or from the side. Cable entries from the top may be accepted provided watertight glands are used.

4.1.2.9 Where the main source of electrical power is essential for propulsion of the ship, the main busbars are to be subdivided into at least two parts which are normally to be connected by circuit breakers (with or without tripping mechanism), disconnecting links or switch by which busbars can be split and reconnected easily and safely. Bolted links (e.g. bolted bus bar sections) are not acceptable. So far is practicable, the connection of generating sets and any other duplicated equipment is to be equally divided among the busbar divisions. Equivalent arrangements to the satisfaction of IRS may be accepted.

4.1.3 Marking and labels

4.1.3.1 All measuring instruments and all apparatus controlling circuits are to be clearly and indelibly marked for identification purposes. An indelible label is to be permanently secured to, or adjacent to, every fuse and every circuit breaker, and marked with particulars of the full load current of the generator or cable which the fuse or circuit-breaker protects. Where inverse time limit and/or reverse current devices are provided in connection with a circuit breaker, the appropriate settings of these devices are to be stated on the lable. The distribution voltage is to be indicated. Labels are to be of flame-retardant material and markings are to correspond with the designations used in the wiring diagrams.

4.1.4 Busbars

4.1.4.1 Busbars and their connections are to be of copper, all connections being so made as to prevent deterioration of the joint by corrosion or oxidation.

4.1.4.2 The sizes of busbars and their connections are to be calculated to ensure that their mean temperature rise does not exceed by more than 45°C from the ambient temperature, when running continuously at the normal rating.

4.1.4.3 Busbars, together with their connections and supports, are to be capable of withstanding, without detrimental effect, the mechanical stresses which will arise during short-circuits. Further, provision is to be made to allow the busbars to expand without causing any abnormal stress on their supports.

4.1.4.4 Busbars and other bare conductors are to be mounted on non- deteriorating and non-hygroscopic insulating material, maintaining adequate clearance and creepage distance, in accordance with Section 1, to ensure that there is no risk of flash-over under normal service conditions. Where necessary these distances may have to be increased to allow for the electro-magnetic forces involved.

4.1.4.5 Connections from bus-bars and from generator circuit terminals to all circuit breakers and fuses are to be installed "short-circuit proof", i.e. either bare conductors, or insulated conductors or single-core cable without metallic sheath/armour /braid are used and these are mounted on supports of insulating material and with adequate distance between the different poles (phases) and to earthed parts.

4.1.4.6 Horizontally installed bus-bars and bare conductors are to be protected by screens, if they are placed so low that it could be a risk, e.g. by tools falling on them.

4.1.5 Equalizer connections

4.1.5.1 The current rating of equalizer connections and equalizer switches is to be not less than half the rated full load current of the generator.

4.1.5.2 The current rating of equalizer busbars is to be not less than half the rated full load current of the largest generator in the group.

4.1.6 Instruments for direct current generators

4.1.6.1 For generators not arranged to run in parallel, at least one voltmeter and one ammeter are to be provided for each generator.

4.1.6.2 For generators arranged to run in parallel at least one ammeter for each generator and two voltmeters are to be provided. One of these voltmeters is to be permanently connected to the busbars and the other is to be provided with a change-over switch to enable it to be connected to any one generator.

4.1.6.3 For compound wound generators fitted with equalizer connections, the ammeter is to be connected to the pole opposite to that connected to the series winding of the generator.

4.1.7 Instruments for alternating current generators

4.1.7.1 For alternating current generators not arranged to run in parallel, each generator is to be provided with at least one voltmeter, one frequency meter, and one ammeter with an ammeter switch to enable the current in each phase to be read or an ammeter in each phase.

Generators above 50 kVA are to be provided with a wattmeter.

4.1.7.2 For alternating current generators arranged to run in parallel, each generator is to be provided with a wattmeter, and an ammeter in each phase conductor or an ammeter with a selector switch to enable measurement of current in each phase.

4.1.7.3 For paralleling of the generators, two voltmeters, two frequency meters and a synchronising aid comprising either a synchroscope and lamps, or an equivalent arrangement, are to be provided. One voltmeter and one frequency meter are to be connected permanently to the busbars, the other voltmeter and frequency meter are to be provided with arrangements to enable the voltage and frequency of any generator to be measured.

4.1.8 Instrument scales

4.1.8.1 In general main switchboard instruments are to be of accuracy class 1.5 and other switchboard instruments are to be of accuracy class 2.5.

4.1.8.2 The upper limit of the scale of every voltmeter is to be approximately 120 per cent of the normal voltage of the circuit, and the normal voltage is to be clearly indicated.

4.1.8.3 The upper limit of the scale of every ammeter is to be approximately 130 per cent of the normal rating of the circuit in which it is installed. Normal full load is to be clearly indicated.

4.1.8.4 Ammeters for use with direct current generators, and wattmeters for use with alternating current generators, which may be operated in parallel, are to be capable of indicating 15 per cent reverse-current or reverse-power respectively.

4.1.8.5 The upper limit of the scale of every wattmeter is to be approximately 130 per cent of the rated full load of the circuit in which it is installed. Rated full load is to be clearly indicated.

4.1.8.6 Frequency meters are to be capable of indicating a variation in the frequency from minus 8 per cent to plus 8 per cent of the nominal frequency of the installation.

4.1.8.7 Instruments are to have effective screening, for example, by metal enclosures, in order to diminish faulty readings caused by induction from adjacent current-carrying parts.

4.1.9 Instrument transformers

4.1.9.1 The secondary windings of instrument transformers are to be earthed.

4.1.10 Circuit-breakers

4.1.10.1 Circuit-breakers are to comply with IEC Publication 947-1 and 947-2, "Low Voltage Distribution Switchgear" or an equivalent national standard, amended where necessary for ambient temperature.

4.1.10.2 Test reports, based on the requirements of IEC Publication 947-1 and 947-2 or an equivalent national standard, are to be submitted for consideration when required.

4.1.10.3 Circuit-breakers are to be of the trip-free type i.e. the breaking action initiated by short-circuit and overcurrent relays, or by undervoltage coil, when fitted, is to be fulfilled independently of the position or operation of manual handle or of other closing devices. Further the arrangement is to be such that automatic repeated breakings/makings by short-circuits and overcurrents cannot occur.

4.1.10.4 Each circuit opening device is to be so arranged that accidental closing and opening does not occur.

4.1.10.5 Handles and operating mechanisms are to be so arranged that the hand of the operator cannot accidentally touch live metal or be injured through an arc arising from the switch or circuit-breaker, or the rupturing of a fuse. If switches are enclosed their handles are not to operate through unprotected slots.

4.1.11 Fuses

4.1.11.1 Fuses are to comply with IEC Publication 269 "Low Voltage Fuse with High Breaking Capacity" or an equivalent national standard, amended where necessary for ambient temperature.

4.1.11.2 A report, giving details of test performance, fusing characteristics, temperature and insulation tests and details of the specification to which the fuse has been tested is to be submitted for consideration when required.

4.1.11.3 Fuse-links and fuse-bases are to be marked with particulars of rated current and rated voltage. Each fuse position is to be permanently and indelibly labeled with the current-carrying capacity of the circuit protected by it and with the appropriate approved size of fuse.

4.1.12 Earthing

4.1.12.1 A good, reliable earth connection of all metallic non-current carrying parts is to be insured. Normally, a continuous earth bar will be required. If other solutions are chosen, earth-continuity test may be required.

4.1.12.2 If components such as switches, instruments, signal lamps, etc. with voltage exceeding 30V AC and 50V DC are mounted on hinged doors of switchboards or other enclosures, the doors are to be connected to the switchboards or enclosures by a separate flexible earth conductor.

4.1.12.3 Earth conductors are to be so installed that they are not likely to suffer mechanical damage or corrosion. The earth conductor is to be carried to a separate earth screw inside the enclosure of the equipment which is earthed, except when separately installed earth conductors are used.

4.1.12.4 Earth conductors inside switchboards and other enclosures are to be insulated, except when the arrangement is such that the earth conductor cannot come into contact with current-carrying parts.

4.1.13 Wiring

4.1.13.1 Insulated cables / wires connecting components are to be stranded, flame retardant and manufactured in accordance with a relevant and acceptable National Standard or equivalent International Standard.

4.2 Distribution switchboards

4.2.1 Large distribution switchboards are to be constructed in accordance with 4.1.

4.2.2 All parts which require operation in normal use are to be placed on the front or easily accessible from behind front doors.

When such parts are placed behind front doors, the interior front is to comply with enclosure type IP 20, except that fuses with accessible current-carrying parts may be permitted, provided that the door is lockable.

4.2.3 Switchboards, supplied from different supply circuits, are not to be placed in the same enclosure unless these are separated by partitions of flame retardant material.

4.2.4 Switchboards, which are provided with two or more supply circuits arranged for automatic standby connection, are to be provided with positive means to show the circuit feeding the switchboard. Such switchboards are to be provided with warning notice that all the supply circuits are to be disconnected before maintenance work is undertaken.

4.2.5 If distribution switchboards are placed in accommodation area then they are also to comply with the requirements given in Pt.6, Ch.3, Cl.3.2.2.3.2 IR.6.

4.3 Navigation lights

4.3.1 Navigation lights are to be connected separately to a distribution board reserved for this purposes only, and connected directly or through transformers to the main or emergency switchboard. The distribution board is to be accessible to the officer of the watch on the bridge. Provision is to be made on the bridge for such navigation lights to be transferred to an alternate circuit.

4.3.2 Each navigation light is to be controlled and protected in each insulated pole by a switch and fuse or circuit breaker mounted on the distribution board.

4.3.3 Where the navigation panel is situated in the midships house, the midships sub-switchboard is regarded as an extension to the main switchboard provided that it is supplied from the main switchboard by two cables each capable of carrying the full load.

4.3.4 Each navigation light is to be provided with an automatic indicator giving audio and visual indication of failure of the light. If a visual signal is used connected in series with the navigation light, means are to be provided to prevent extinction of the navigation light due to failure of the signal.

4.3.5 Transferring of power supply to an alternate circuit should not render the audio/visual alarms inoperative. Means should be provided to test the audio/visual alarms.

4.3.6 Any statutory requirements of the country of registration are to be complied with and, on application to IRS, may be accepted as an alternative to the above.

4.3.7 The voltage drop between the power supply terminals and load terminals for navigation lights is to be not more than 2.5 per cent of the rated voltage to ensure required output and colour.

4.4 Control gear

4.4.1 Control gear is to comply with IEC 60947 "Low-voltage switchgear and control gear" or an equivalent national standard, amended where necessary for ambient temperature.

4.4.2 Control gear, including isolating and reversing switches, is to be so arranged that shunt field circuits are not disconnected without adequate discharging path being provided.

4.4.3 Control gear for essential and important motors are to be separated from each other and from other current carrying parts by screens. The arrangement is to be such that maintenance work can be carried out on each unit without danger when isolated.

4.4.4 When installed in main switchboards motor control gear is to be placed in separate cubicles separated from all other parts of the switchboard by partitions of flame retardant material. The arrangements are to be such that arcs occurring by short-circuit in one cubicle cannot spread to bus-bars.

4.5 Testing

4.5.1 Switchgear and control gear assemblies with supply voltage of 60 V and above are to be tested as follows:

- High voltage test with 1000 V plus twice the rated voltage with a minimum of 2000 V. The test voltage is to be supplied for 1 minute at any frequency between 25 and 100 Hz.

- Insulation resistance measuring.

4.5.2 Switchgear and control gear assemblies with supply voltage less than 60 V are to be tested in accordance with 4.5.1 except that the test voltage is to be 500 V.

Section 5

Rotating Machines - Construction and Testing

5.1 General

5.1.1 Rotating machines are to comply with the relevant part of IEC Publication IEC 60092-301, or an acceptable and relevant national standard, and the requirements of this Section.

5.1.2 For all the rotating machines for essential services, manufacturer's test records are to be provided (See also Sec.1). For other machines they are to be available upon request.

5.1.3 Shaft materials for electric propulsion motors and for main engine driven generators where the shaft is part of the propulsion shafting, is to comply with applicable requirements of Pt.2, and to be certified by IRS. Shaft material for other machines is to be in accordance with either Pt.2 or recognised international or national standard.

5.1.4 The rotating parts are to be so balanced that when running at any speed in the normal working range the vibration level does not exceed the levels specified in IEC 60034.

5.1.5 The lubrication arrangement for bearings are to be effective under all operating conditions including the maximum ship inclinations specified in Ch.1 and there are to be effective means to ensure that lubricant does not reach the machine windings or other conductors and insulators.

5.1.6 Steps are to be taken to prevent the ill effects of flow of currents circulating between the shaft and bearings.

5.1.7 Where welding is proposed to be applied to shafts of machines for securing armature arms or spiders, stress relieving is to be carried out after welding. The proposal is to be submitted for scrutiny and approval.

5.1.8 The construction of alternating machines, are to be capable of withstanding a sudden short circuit at their terminals under any operating condition.

5.1.9 Effective means are to be provided to prevent the accumulation of moisture and condensation within the machines when they are stopped with a provision that such means are switched on at stand-still and switched off at starting.

5.1.10 Coolers : Water-air heat exchangers of rotating machines are to be of the double tube type. In a normally attended position a visual and audible alarm is to be given to monitor water cooler leakage.

5.2 Rating

5.2.1 Ship's service generators including their exciters, and continuously rated motors are to be suitable for continuous duty at their full rated output at maximum cooling air or water temperature for an unlimited period, without the limits of temperature rise in 5.3 being exceeded. Other generators and motors are to be rated in accordance with the duty which they are to perform, and when tested under rated load conditions the temperature rise is not to exceed the values in 5.3.

5.3 Temperature rise

5.3.1 The limits of temperature rise specified in Table 5.3.1 are based on a cooling air temperature of 45°C and a cooling water temperature of 30°C.

5.3.2 If the temperature of the cooling medium is known to exceed the value given in 5.3.1, the permissible temperature rise is to be reduced by an amount equal to the excess temperature of the cooling medium. These temperature rises are, if necessary to be reduced to satisfy the requirements of flame-proof equipment.

5.3.3 If the temperature of the cooling medium is known to be permanently less than the value given in 5.3.1, the permissible temperature rise may be increased by an amount equal to the difference between the declared temperature and that given in 5.3.1 upto a maximum of 15°C.

Table 5.3.1 : Limits of temperature rise in °C

Item		Part of machines	Method of measurement of temp.	Temperature rise °C					
				Air cooled machines insulation class			Water cooled machines insulation class		
				A	E	B	A	E	B
1	(a)	a.c. windings of turbine type machines having output of 5000 KVA or more	ETD or R	50	60	70	70	80	90
	(b)	a.c. windings of salient-pole and of induction machines having output of 5000 KVA or more, or having a core length of one metre or more	ETD or R	50	60	70	70	80	90
2	(a)	a.c. windings of machines smaller than in item 1	R	50	65	70	70	85	90
			T	40	55	60	60	75	80
	(b)	Field windings of a.c. and d.c. machines having d.c. excitation other than those in items 3 and 4	R	50	65	70	70	85	90
			T	40	55	60	60	75	80
	(c)	Windings of armatures having commutators	R	50	65	70	70	85	90
			T	40	55	60	60	75	80
3		Field windings of turbine-type machines having d.c. excitation	R	-	-	80	-	-	100
4	(a)	Low-resistance field windings of more than one layer and compensating windings	T,R	50	65	70	70	85	90
	(b)	Single-layer windings with exposed bare surfaces	T,R	55	70	80	75	90	100
5		Permanently short-circuited insulated windings	T	50	65	70	70	85	90
6		Permanently short-circuited windings, uninsulated	T	The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts					
7		Iron core and other parts not in contact with windings	-	The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on adjacent parts					
8		Iron core and other parts in contact with windings	T	50	65	70	70	85	90
9		Commutators and slip-rings, open or enclosed	T	50	60	70	70	80	90

Table 5.3.1 (Contd.)

Notes:-

1 T = Thermometer method
R = Resistance method
ETD = Embedded Temperature Detector

2 When the commutators, sliprings or bearings of machines provided with water coolers are not in the enclosed air circuits-cooled by the water cooler, but are cooled by the ambient cooling air, the permissible temperature rise above the ambient cooling air should be the same as for ventilated machines.

3 When Class F or Class H insulation is employed, the permitted temperature rises are respectively 20°C and 40°C higher than the values given for Class B insulation.

4 Classes of insulation are to be in accordance with IEC Publication 85 (1957) - "Recommendations for the classification of material for the insulation of electrical machinery and apparatus in relation to their thermal stability in service".

5.3.4 The limits of temperature rise of electric slip couplings are to be in accordance with Table 5.3.1, except that when a squirrel cage element is used the temperature of this element is not to reach an injurious value. The temperature of the field windings is not to exceed these limits at all speeds of operation. Arrangements for reducing the excitation of self ventilated couplings at low operational speeds are permissible.

5.3.5 Alternating current machines of 5000 kVA output and above and propulsion motors having a total axial core length of 1m or more (including the ventilating duct), are to have at least three embedded temperature detectors. With multicore machines the total length is to be taken as the sum of the individual core lengths.

5.4 Generator control

5.4.1 Each alternating current generator, unless of the self-regulating type, is to be provided with automatic means of voltage regulation; voltage build-up is not to require an external source of power.

5.4.2 The voltage regulation of any alternating current generator with its regulating equipment is to be such that at all loads, from zero to full load at rated power factor, the rated voltage is maintained within ±2.5 per cent under steady conditions. There is to be provision at the voltage regulator to adjust the generator no load voltage.

5.4.3 Generators, and their excitation systems, when operating at rated speed and voltage on no-load are to be capable of absorbing the suddenly switched, balanced, current demand of the largest motor or load at a power factor not greater than 0.4 with a transient voltage dip which does not exceed 15 per cent of rated voltage. The voltage is to recover to rated voltage within a time not exceeding 1.5 seconds.

5.4.4 The transient voltage rise at the terminals of a generator is not to exceed 20 per cent of rated voltage when rated KVA at a power factor not greater than 0.8 is thrown off.

5.4.5 Generators are to be capable of maintaining under steady state short circuit conditions a current of at least three times the full load rated current for a duration of at least two seconds or where precise data is available for the duration of any longer time delay which may be provided by a tripping device for discrimination purposes.

5.4.6 Generators required to run in parallel are to be stable from no load [kW] up to the total combined full load [kW] of the group, and load sharing is to be such that the load on any generator does not normally differ from its proportionate share of the total load by more than 15 per cent of the rated output [kW] of the largest machine or 25 per cent of the rated output [kW] of the individual machine, whichever is less.

5.4.7 When generators are operated in parallel, the kVA loads of the individual generating sets are not to differ from the proportionate share of the total kVA load by more than 5 per cent of the rated kVA output of the largest machines.

5.4.8 Generators running in parallel may have a common neutral connection to earth provided they are suitably designed to avoid excessive circulating currents.
This is particularly important if the generators are of different size and make.
Generators in which the third harmonic content of the waveform does not exceed 5 per cent may be considered adequate.

Note : This would mostly occur with a neutral bus with a single grounding resistor with the associated neutral switching. Where individual resistors are used, circulation of the third harmonic currents between paralleled generators is minimized.

5.5 Overloads

5.5.1 Machines are generally to be capable of withstanding, on test, without injury, the following overload conditions :

a) D.C. generators - an excess current of 50 per cent for 15 seconds after attaining the temperature rise corresponding to rated load, the terminal voltage being maintained as near the rated value as possible. This requirement does not apply to the overload torque capacity of the prime mover.

b) A.C. generators - an excess current of 50 per cent for 2 minutes, at 0.6 power factor, after attaining the temperature rise corresponding to rated load, the terminal voltage and frequency being maintained as near the rated values as possible. This requirement does not apply to the overload torque capacity of the prime mover.

c) Motors - At rated speed or in the case of a range of speeds, at the highest and lowest speeds, under gradual increase of torque, the voltage and frequency being maintained as near to their rated value as possible, the appropriate excess torque given below. Synchronous motors and synchronous induction motors are required to withstand the excess torque without falling out of synchronism and without adjustment of the excitation current preset at the value corresponding to rated load.

d.c. motors	50 per cent for 15 seconds
polyphase a.c. synchronous motors	50 per cent for 15 seconds
polyphase a.c. synchronous induction motors	35 per cent for 15 seconds
polyphase a.c. induction motors	60 per cent for 15 seconds

d) Propulsion machines - Overload tests for propulsion machines will be given special consideration for each installation.

5.6 Brushgear

5.6.1 The final running position of brushgear is to be clearly and permanently marked.

5.6.2 Direct current motors and generators are to operate with fixed brush setting from no load to the momentary overload specified without injurious sparking, or damage to the commutator or brushes. The commutation is to be checked with an excess current of 20 per cent and for a period of time sufficient to judge its quality.

5.6.3 Alternating current commutator motors are to operate over the specified range of load and speed without injurious sparking.

5.7 Inspection and testing

5.7.1 On all machines intended for essential services, tests specified in Table 5.7.1 are to be carried out. See also Section 1 'Surveys', subsection 1.3. Any other relevant tests required by the national standards are also to be carried out.

Type tests are to be carried out on a prototype machine or on the first of a batch of machines and routine tests carried out on subsequent machines.

5.7.2 The high voltage test is to be carried out at 1000 plus twice the rated voltage with a minimum of 2000 V on new machines, preferably at the conclusion of the temperature rise test. The test is to be applied between the windings and the frame with the core connected to the frame and to any windings or sections of windings not under test. Where both ends of each phase are brought out to accessible separate terminals, each phase is to be tested separately. The test is to be made with alternating voltage at any convenient frequency between 25 and 100 Hz of approximately sine wave form. The test is to be commenced at a voltage of not more than one half of the full-test voltage and is to be increased progressively to full value, the time allowed for the increase of the voltage from half to full value being not less than 10 seconds. The full test voltage is then to be maintained for one minute and then reduced to one half full value before switching off.

5.7.3 When additional high voltage tests are required on a machine which has already passed its tests or on machines after repair, the voltage of such further tests is to be 75 per cent of the value given in 5.7.2.

5.7.4 Immediately after the high voltage tests the insulation resistances are to be measured using a direct current insulation tester between:

a) all current carrying parts connected together and earth,

b) all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

The minimum values of test voltages and corresponding insulation resistances are given in Table 5.7.4. The insulation resistance is to be measured close to the operating temperature, or an appropriate method of calculation is to be used.

Table 5.7.1 : Tests to be carried out on electrical rotating machines

Sr. No.	**Tests**	**a.c. Generators**		**Motors**	
		Type test (1)	**Routine test (2)**	**Type test (1)**	**Routine test (2)**
1.	Examination of the technical documentation, as appropriate and visual inspection	X	X	X	X
2.	Insulation resistance measurement	X	X	X	X
3.	Winding resistance measurement	X	X	X	X
4.	Verification of the voltage regulation system	X	X		
5.	Rated load test and temperature rise measurement	X		X	
6.	Overload test	X	X(4)	X	X(4)
7.	Verification of steady short-circuit conditions (3)	X			
8.	Overspeed test	X	X	X(5)	X(5)
9.	Dielectric strength test	X	X	X	X
10.	No load test	X	X	X	X
11.	Verification of degree of protection	X		X	
12.	Verification of bearings	X	X	X	X

(1) For machines of less than 100 kW, type tests on prototype machine is acceptable. For 100 kW or more, tests on at least the first of each batch of machines are to be carried out.
(2) The report of machines routine tested is to contain the manufacturer's serial number of the machine which has been type tested and the test results.
(3) Verification of steady short-circuit condition applies to synchronous machines only.
(4) Only applicable for machines of essential services rated above 100 kW. For routine tests, overcurrent test may be carried out in lieu of overload test.
(5) Not applicable for squirrel cage motors.

Table 5.7.4: Minimum values of test voltages and corresponding insulation resistances

Related Voltage V_R (V)	Minimum Test Voltage (V)	Minimum InsulationResistance (MΩ)
$V_R \le 250$	$2 \times V_R$	1
$250 < V_R \le 1000$	500	1
$1000 < V_R \le 7200$	1000	$(V_R / 1000) + 1$
$7200 < V_R \le 15000$	5000	$(V_R / 1000) + 1$

Section 6

Converting Equipment

6.1 Transformers

6.1.1 The following requirements apply to transformers of 5 kVA and above.

6.1.2 Transformers are to comply with the requirements of IEC Publication 76 or an acceptable and relevant national standard amended where necessary for ambient temperature.

6.1.3 Transformers may be of the dry type, encapsulated or liquid filled type.

6.1.4 Transformers are to be placed in easily accessible well ventilated spaces free from any gaseous or acid fumes. They are to be clear of non-protected ignitable materials, and so arranged as to be protected against shocks and any damage resulting from water, oil, liquid fuel, steam etc.

6.1.5 The live parts of transformers are to be provided with means of protection against accidental contact.

6.1.6 Transformers are to be double wound except those for motor starting.

6.1.7 Windings of air cooled transformers are to be treated to efficiently resist moisture, sea air and oil vapours.

Effective means are to be provided to prevent the accumulation of moisture and condensation within the transformers, when de-energized.

6.1.8 Each transformer is to be provided with a nameplate of corrosion- resistant metal giving information on make, type, serial number, insulation class and any other technical data necessary for the application of the transformer.

6.1.9 Liquid fillings for transformers are to be non-toxic and of a type which does not readily support combustion. Liquid filled transformers are to have a pressure relief-device with an alarm and there is to be a suitable means provided to contain any liquid which may escape from the transformer.

6.1.10 When forced cooling is employed, whether air or liquid, there is to be monitoring of the cooling medium and transformer winding temperature with an alarm should these exceed preset limits. There are to be arrangements so that the load may be reduced to a level commensurate with the cooling available.

6.1.11 The inherent regulation of transformers at their rated output is to be such that voltage drop to any point in the installation does not exceed that allowed by 2.3.

6.1.12 All transformers are to be constructed to withstand, without damage, the thermal and mechanical effects of a short-circuit at the terminals of any winding for 2 seconds with rated primary voltage and frequency without damage. This may be required to be verified by type test or random test.

6.1.13 The temperature rise of windings of transformers above the ambient temperatures given in Ch.1, when measured by resistance, during continuous operation at the maximum rating, is not to exceed :

a) For dry type transformers, air cooled

- 50°C for Class A;
- 60°C for Class E;
- 70°C for Class B;
- 90°C for Class F; and
- 110°C for Class H.

b) For liquid filled transformers

- 50°C - where air provides cooling of the fluid;
- 65°C - where water provides cooling of the fluid.

6.1.14 The tests given hereunder are to be carried out on all transformers at the manufacturer's works and a certificate of tests issued by the manufacturer.

a) High voltage test : The test voltage is to be applied, preferably after the temperature rise test, to each winding in turn, between the winding under test and the remaining windings, core, frame and tank or casing connected together and to earth. The test is to be made with 1 kV a.c. plus twice the highest voltage between lines with a minimum of 2.5 KV at any frequency between 25 and 100 Hz and maintained for 1 minute without failure.

b) When additional high voltage tests are carried out and for transformers that have been rewound or subject to extensive repair, the test voltage may be limited to a value which is 75 per cent of that stated in (a).

c) Induced high voltage test : To test between turns, coils and terminals, an a.c. voltage is to be applied between the above parts corresponding to twice the voltage appearing between these parts when rated voltage is applied to the terminals. The duration of the test is to be 1 minute for any test frequency up to and including twice the rated frequency.

d) Insulation resistance : The insulation resistance of each winding in turn to all the other windings, core, frame and tank or casing connected together and to earth is to be measured after the high voltage test and recorded together with the temperature of the transformer at the time of the test.

e) Temperature rise : One transformer of each size and type is to be given a temperature rise test. For transformers of rating 100 KVA and above, it will be accepted that the temperature rise test is made on one of several identical transformers manufactured and tested at the same time.

6.2 Semiconductor equipment

6.2.1 The requirements of 6.2.2 to 6.2.16 apply to semiconductor equipment rated for 5 [kW] upwards.

6.2.2 Semiconductor equipment is to comply with the requirements of IEC 146: Semiconductor convertors, or an acceptable and relevant national standard amended where necessary for ambient temperature.

6.2.3 Semiconductor static power converter equipment is to be rated for the required duty having regard to peak loads, system transients and overvoltage.

6.2.4 Converter equipment may be air or liquid cooled and is to be so arranged that it cannot remain loaded unless effective cooling is maintained. Alternatively the load may be automatically reduced to a level commensurate with the cooling available.

6.2.5 Liquid cooled converter equipment is to be provided with leakage alarms and there is to be a suitable means provided to contain any liquid which may leak from the system. Where the semiconductors and other current carrying parts are in direct contact with the cooling liquid, provision is to be made for monitoring the liquid to ensure it has a satisfactory resistivity.

6.2.6 Where forced cooling is used there is to be temperature monitoring of the heated cooling medium with an alarm and shutdown when the temperature exceeds a preset value.

6.2.7 Cooling fluids are to be non-toxic and of low flammability.

6.2.8 Converter equipment is to be so arranged that the semiconductor devices, fuses, control and firing circuit boards may be readily removed from the equipment for repair or replacement.

6.2.9 Test and monitoring facilities are to be provided to permit identification of control circuit faults and faulty components.

6.2.10 Protection devices fitted for converter equipment protection are to ensure that, under fault conditions, the protective action of circuit breakers, fuses or control systems is such that there is no further damage to the convertor or the installation.

6.2.11 Converter equipment, including any associated transformers, reactors, capacitors and filters, if provided, is to be so arranged that the harmonic distortion, and voltage spikes, introduced in to the ships electrical system are restricted to a level necessary to ensure that it causes no malfunction of equipment connected to the electrical installation.

6.2.12 Overvoltage spikes or oscillations caused by commutation or other phenomena, are not to result in the supply voltage waveform deviating from the superimposed equivalent sine wave by more than 10 percent of the maximum value of the equivalent sine wave.

6.2.13 When converter equipment is operated in parallel, load sharing is to be such that under normal operating conditions overloading of any unit does not occur and the combination of parallel equipment is stable throughout the operating range.

6.2.14 When converter equipment has parallel circuits there is to be provision to ensure that the load is disturbed uniformly between the parallel paths.

6.2.15 Transformers, reactors, and other circuit devices associated with convertor equipment are to be suitable for the distorted voltage and current waveforms to which they may be subjected.

6.2.16 Tests at the manufacturer's works are to include

- high voltage test for one minute applied between terminals and earthed parts at a frequency between 25 - 100 Hz. For system voltage up to 60 V the test voltage is to be 600 V; for system voltage between 60 - 90 V the test voltage is to be 900 V; for system voltage over 90 V the test voltage is to be twice the system voltage plus 1000 V;

- functional tests;

- temperature rise test; and

- such other agreed tests as are necessary to demonstrate the suitability of the equipment for its intended duty. Details of tests are to be submitted for consideration when required.

Section 7

Miscellaneous Equipment

7.1 Accumulator batteries

7.1.1 General

7.1.1.1 The requirements of this Section apply to permanently installed secondary batteries of the vented type.

7.1.1.2 A vented type battery is one in which the electrolyte can be replaced and which may release gas whilst operating on charge and overcharge.

7.1.1.3 Proposals for the use of other types of secondary batteries may be submitted for consideration.

7.1.2 Construction

7.1.2.1 The cells of all vented type batteries are to be so constructed and secured as to prevent spilling of the electrolyte due to inclinations of 40 degrees from normal. The filling plugs are to be so constructed as to prevent spilling of electrolyte due to ship's movements, e.g. rolling and pitching.

7.1.2.2 All batteries are to be provided with durable labels of flame retardant material, giving information on the application for which the battery is intended, voltage and capacity. Instructions are to be fitted either at the battery or at the charging device giving information on maintenance and charging.

7.1.3 Location

7.1.3.1 Alkaline batteries and lead acid batteries of the vented type are not to be installed in the same compartment.

7.1.3.2 Batteries are to be located in such a manner that they are not exposed to excessive heat, extreme cold, spray, steam or other conditions which would impair performance or accelerate deterioration.

7.1.3.3 Batteries are not to be located in an accommodation space.

7.1.3.4 Large batteries are to be installed in a compartment assigned to them only. A box on deck would meet this requirement if adequately ventilated and provided with means to prevent ingress of water, and provided the intended service is assured in cold conditions.

7.1.3.5 Engine starting batteries are to be located as close as practicable to the engine(s) served. If such batteries cannot be accommodated in the battery compartment, they are to be installed so that adequate ventilation is ensured.

7.1.4 Installation

7.1.4.1 Batteries should be so arranged that each cell or crate of cells is accessible from the top and at least one side.

7.1.4.2 Cells or crates are to be carried on non-absorbent insulating supports. Similar insulators are to be fitted to prevent any movement of cells arising from the motion of the vessel. Adequate space for circulation of air is to be ensured.

7.1.4.3 Where acid is used as the electrolyte for a vented type battery, a tray of acid resisting material is to be provided below the cells unless the deck below is similarly protected.

7.1.4.4 The interiors of all compartments for vented type batteries, including the shelves, are to be painted with corrosion resistant paint with consideration given to the type of electrolyte actually used.

7.1.4.5 A permanent notice is to be fitted to all compartments for vented type batteries prohibiting naked lights and smoking in the compartment.

7.1.5 Ventilation

7.1.5.1 Battery compartments, lockers and boxes are to be adequately ventilated by an independent ventilating system to avoid accumulation of inflammable gases. Particular attention should be given to the fact that these gases are lighter than air and tend to accumulate at the top of the spaces.

7.1.5.2 The battery compartment is to be provided with an effective air inlet near the floor level.

7.1.5.3 Natural ventilation may be employed if ducts of adequate size can be run directly from the top of the compartment to the open air with no part of the duct more than 45 degrees from the vertical. If natural ventilation is impracticable, mechanical ventilation providing at least 30 changes of air per hour is to be installed. Interior surfaces of ducts and fans are to be painted with corrosion-resistant paint. Fan motors are not to be located in the air stream.

7.1.5.4 Necessary precautions are to be taken to prevent sparking due to possible contact by the ventilation fan blades with fixed parts.

7.1.5.5 All openings through the battery compartment bulkheads or decks, other than ventilation openings, are to be effectively sealed. (Also refer Pt.6, Ch.2, Cl.2.2.1).

7.1.6 Electrical equipment

7.1.6.1 Switches, fuses and other electrical equipment liable to cause an arc should not normally be installed in battery compartments. Where such equipment is necessary for operational reasons, the equipment should be certified for Group II C gases and temperature Class T1 in accordance with IEC 79, "Electrical Apparatus for Explosive Gas Atmospheres" or an equivalent national standard.

7.1.6.2 Cables, with the exception of those pertaining to the battery or the local lighting, are not to be installed in battery compartments except where installation in other locations is impracticable.

7.1.7 Number and rating of batteries

7.1.7.1 Where batteries are used for starting main engines, at least two batteries are to be fitted of such combined size that requirements of Ch.4 are complied with.

7.1.8 Charging facilities

7.1.8.1 All batteries are to be provided with charging devices, suitable for the actual service. Generally, automatically regulated charging devices are to be used, operating as floating service with the battery and giving trickle-charging when the battery is fully charged, or with change-over arrangement for full(quick)-charging and automatic trickle-charging. Other forms for charging arrangements, e.g. charging through resistors from a DC net with higher voltage, will be specially considered.

7.1.8.2 In direct current systems means are to be provided to isolate the batteries from the low voltage systems when being charged from a higher voltage system.

7.1.8.3 Charging devices are to be provided with suitable switch and fuse gear for protection against faults such as short circuit, overload and connection failures.

7.1.9 Maintenance of records for batteries

a) Where batteries are fitted for use for essential and emergency services a schedule of such batteries is to be compiled and maintained. The schedule, which is to be submitted for review during new building survey and subsequently verified during annual surveys, is to include at least the following information regarding the battery(ies):

   - Type and manufacturer’s type designation
   - Voltage and ampere-hour rating
   - Location
   - Equipment and/or system(s) served
   - Maintenance / replacement cycle dates
   - Date(s) of last maintenance and/or replacement
   - For replacement batteries in storage, the date of manufacture and shelf life.[1)]

b) Procedures are to be put in place to ensure that when batteries are replaced, they are of an equivalent type.

c) Where vented[2)] type batteries replace valve-regulated sealed[3)] types, it is to be ensured that there is adequate ventilation[4)] and that IRS requirements relevant to the location and installation of vented types batteries are complied with.

d) Details of the schedule and of the procedures are to be included in the ship's safety management system and be integrated into the ship's operational maintenance routine.

Notes:

1) Shelf life is the duration of storage under specified conditions at the end of which a battery retains the ability to give a specified performance.

2) A vented battery is one in which the cells have a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere.

3) A valve-regulated battery is one in which cells are closed but have an arrangement (valve) which allows the escape of gas if the internal pressure exceeds a predetermined value.

4) The ventilation arrangements for installation of vented type batteries which have charging power higher than 2kW are to be such that the quantity of air expelled is at least equal to:

$Q = 110\, l\, n$

where,

n = number of cells in series

l = maximum current delivered by the charging equipment during gas formation, but not less than 25 percent of the maximum obtainable charging current in amperes.

Q = quantity of air expelled in litres/hr.

The ventilation rate for compartments containing valve-regulated batteries may be reduced to 25 per cent of that given above.

7.2 Luminaries - construction and testing

7.2.1 General

7.2.1.1 Lighting which is essential for safety and working is to comply with the following provisions.

7.2.1.2 Lighting fittings installed in engine rooms or similar spaces where they are exposed to the risk of mechanical damage are to be provided with suitable grilled mechanical guards to protect their lamps and glass globes against such damage.

7.2.1.3 Precautions are to be taken so that a lamp for one voltage cannot be inserted in a lampholder for another voltage.

7.2.2 Incandescent lighting

7.2.2.1 The voltage of tungsten filament lampholders is not to exceed:

a) Bayonet fitting

Normal	B22 250 V
Small (single contact)	B15 s 130 V
Small (double contact)	B15 d 130 V

b) Screw fitting

Goliath	E40 250 V
Medium	E27 250 V
Small	E14 250 V
Miniature	E10 24 V

7.2.2.2 Lamps are to be in accordance with the following :

B22	upto 200 W
E27	upto 200 W
E40	upto 3000 W

7.2.2.3 Lampholders are to be constructed of flame-retarding and non- hygroscopic material. All metal parts are to be of robust construction. Goliath lampholders are to be provided with means for locking the lamp in the holder. The temperature of cable connections is not to exceed the maximum conductor temperature permitted for the cable as given in Table 3.3.1.

7.2.3 Fluorescent lighting

7.2.3.1 The ratings of tubular fluorescent lamps are not to exceed 250 V and 80 W.

7.2.3.2 Fittings, reactors, capacitors and other auxiliaries are not to be mounted on surfaces which are subject to high temperatures.

7.2.3.3 Capacitors of 0.5mF and above are to be provided with a means of prompt discharge on disconnection of the supply.

7.2.4 Discharge lighting

7.2.4.1 Where cold cathode luminous discharge lamps of normal operating voltage above 250 V are used, a warning notice calling attention to the voltage is to be displayed at points of access to the lamps and where otherwise necessary.

7.2.4.2 Inductance and high reactance transformers are to be installed as close as practicable to the associated discharge lamp.

7.2.4.3 Every capacitor of 0.5mF or more is to be provided with means for reducing the voltage of capacitor to less than 55V within one minute after disconnections from supply source.

7.2.4.4 All live parts of discharge lamp luminaries are to be so designed, placed and installed that they cannot be touched accidentally or inadvertently. The creepage distance along the surface of the glass tube is to be taken into considerations.

7.2.4.5 All parts of searchlights or arc lamps to be handled for their operations or adjustment while in use, are to be so arranged that there is no risk of shock to the operator. Disconnection of every searchlight or arc lamp is to be by a multi-pole disconnecting switches.

If a series resistor is used with an arc lamp, the disconnecting switch is to be so placed in the supply circuit that both the series resistor and arc lamp are disconnected when the switch is in the "off" position.

7.3 Accessories - Construction and testing

7.3.1 Enclosures

7.3.1.1 Enclosures are to be of metal or of flame-retardant insulating materials.

7.3.2 Inspection and draw boxes

7.3.2.1 If metal conduit systems are used, inspection and draw boxes are to be of metal and are to be in rigid electrical and mechanical connection with the conduits.

7.3.3 Socket outlets and plugs

7.3.3.1 The temperature rise on the live parts of socket outlet and plugs is not to exceed 30°C.

7.3.3.2 Socket outlets and plugs are to be so constructed that they cannot be readily short-circuited whether the plug is in or out, and so that a pin of the plug cannot be made to earth either pole of the socket outlet.

7.3.3.3 All socket outlets of current rating 16 A or more are to be provided with a switch so interlocked that the plug cannot be inserted or withdrawn with the switch in the "ON" position.

7.3.3.4 Where it is necessary to earth the non-current-carrying parts of portable or transportable equipment, an effective means of earthing is to be provided at the socket outlet.

7.3.3.5 Where distribution systems with different voltages are in use, the socket outlets and plugs are to be of such design that a plug for one voltage cannot be inserted into the socket outlet for a different voltage.

7.3.3.6 On weather decks, galleys, laundries, machinery spaces and all wet situations socket outlets and plugs are to be effectively shielded against rain and spray and are to be provided with means for maintaining this quality after removal of the plug.

7.4 Heating and cooking equipment

7.4.1 Heaters are to be so constructed, installed and protected that clothing, bedding and other inflammable material cannot come in contact with them in such a manner as to cause risk of fire. There is to be no excessive heating of adjacent bulkheads or decks.

7.4.2 Parts of heaters or cooking appliances which must necessarily be handled should not become heated to a temperature exceeding 55°C for metallic parts and 65°C for nonmetallic parts; for other parts the temperatures obtained in service are to be such that the various materials are not subjected in the course of normal working to any excessive thermal stress.

7.4.3 Each separate element rated more than 15 A is considered as a separate consumer, for which a separate circuit from a switchboard or distribution board is required.

7.5 Lightning conductors

7.5.1 General

7.5.1.1 Lightning conductors are to be fitted to each mast of all wood, composite, and steel ships having masts or topmasts of wood or other non-conductive material. They need not be fitted to steel ships having steel masts, unless the mast is partly or completely insulated from the ship's hull.

7.5.2 Construction

7.5.2.1 In wooden and composite ships fitted with wooden masts, the lightning conductors are to be composed of continuous copper tape and/or rope, having a Section not under 100 [mm^2]. These are to be riveted with copper rivets or fastened with copper clamps to an appropriate copper spike not less than 13 [mm] in diameter and projecting at least 150 [mm] above the top of the mast. If tape is used the lower end of the tape is to terminate at the point at which the shrouds leave the mast, and is to be securely clamped to a copper rope of not less than 13 [mm] diameter. This copper rope is to be led down the shrouds and is to be securely clamped to a copper plate having an area of at least 0.2 [m^2]. This copper plate is to be fixed to the ship's hull well below the light load waterline in such a manner that it is to be immersed under all conditions of heel.

7.5.2.2 In wooden and composite ships fitted with steel masts, each mast is to be connected to a copper plate in accordance with 7.5.2.1. The copper rope is to be securely attached to and in good electrical contact with the mast at or above the point at which the shrouds leave the mast.

7.5.2.3 In steel ships fitted with wooden masts, the lightning conductors are to be composed of copper tape or rope terminating in a spike in accordance with 7.5.2.1. At the lower end this copper tape or rope is to be securely clamped to the nearest metal forming part of hull of the ship.

7.5.2.4 Lightning conductors are to be run as straight as possible, and sharp bends in the conductors are to be avoided. All clamps used are to be of brass or copper, preferably of the serrated contact type, and efficiently locked. Soldered connections are not acceptable.

7.5.2.5 The resistance of the lightning conductors, measured between the mast head and the position on the earth plate or hull to which the lightning conductor is earthed, is not to exceed 0.02 ohms.

7.5.2.6 Suitable means should be provided to enable ships when in drydock or on a slipway to have their lightning conductors or steel hulls connected to an efficient earth on shore. When the ships are in floating docks, suitable means should be provided for earthing these lightning conductors to the sea.

Section 8

Electric Propulsion Systems

8.1 General

8.1.1 All electric propelling machinery including switchgear, control gear, cables, main and auxiliary generators, motors, exciters and electro-magnetic coupling, is to comply with the relevant Chapter/Sections of the Rules and is to be constructed under Special Survey.

8.1.2 Prime movers are to comply with the relevant Section(s) of Ch.4.

8.1.3 Armature shafts and other important steel forgings and castings are to comply with the requirements of Pt.2.

8.1.4 The torsional vibration characteristics of the propulsion system are to be submitted as required by Ch.4, as applicable.

8.1.5 Cooling water and lubricating oil systems are to comply with Ch.3, where applicable.

8.1.6 Where the arrangements permit a propulsion motor to be connected to a generating plant having a continuous rating greater than the motor rating, means are to be provided to limit the continuous full load torque for which the motor and shafts are approved.

8.1.7 The torque available for maneuvering is to be greater than the trailing torque of the propeller and of sufficient magnitude to be capable of stopping the propeller and reversing its direction of rotation (within a reasonable time) when the vessel is underway at the maximum service speed. In alternating current installations the power torque is to be sufficiently high to ensure that there is no risk of the motor pulling out of step in bad weather or when turning in the case of vessels having several lines of shafting.

8.1.8 Motors and generators of 400 [kW] or over are to be provided with means of heating the windings to prevent condensation when idle. If steam pipes are used for this purpose the joints are not to be within the machine.

8.2 Excitation

8.2.1 Systems dependent on the auxiliary generators for excitation are to be capable of maneuvering and of maintaining power at all times with a fall of 10 per cent excitation voltage at the busbars.

8.2.2 Where motor driven exciters, boosters, balancers or rectifiers are provided for excitation purposes, provision for an alternative supply of excitation is to be made. Where two machines are used, each of at least 50 per cent of the required power, it will be sufficient to provide one spare machine.

8.2.3 Negative boosters are to be provided with overspeed protection where necessary.

8.2.4 In direct current constant pressure systems, arrangements for generator and motor excitation are to be such that if the motor excitation circuit is opened by a switch or contactor, the generator excitation is simultaneously interrupted, or the generator voltage is immediately reduced to zero.

8.3 Maneuvering controls

8.3.1 In addition to the requirements of Ch.7, the following provisions are to be complied with.

8.3.2 Where bridge or deck control is employed, alternative control in the engine room is to be provided.

8.3.3 Suitable interlocks, operating preferably by mechanical means, are to be provided to prevent damage to the plant as a result of incorrect switching, such as the opening of switches or contactors not intended to be operated while carrying current or such as the simultaneous closing of the ahead and astern circuits.

8.3.4 Provision is to be made for the manual operation, without undue manual effort, of all maneuvering contactors, switches, field regulators and controllers. Where electric, pneumatic or hydraulic aid is used for normal operation, failure of such aid is not to result in interruption of power to the propeller shaft and any such device is to be capable of purely manual operation without delay. This latter requirement does not apply to bridge control equipment.

8.3.5 In propulsion installations with two or more generators or two or more motors on one line of shafting the propulsion circuit is to be so arranged that any of these machines can be cut out of the circuit without preventing the others from working.

8.3.6 Where steam and oil gauges are mounted on the main control station, provisions are to be made so that in case of leakage, steam or oil may not come into contact with the energized parts.

8.3.7 Alternative arrangements will be specially considered.

8.4 Cables

8.4.1 Conductors in circuits essential for maneuvering or maintenance of propelling power are to be stranded, having not less than seven strands, and are to have a nominal cross-sectional area of not less than 2.5 [mm^2].

8.4.2 Cables which are connected to the slip rings of synchronous motors are to be suitably insulated for the voltage to which they are subjected during maneuvering.

8.4.3 Cable ends are to be fitted with connectors or connecting sockets of appropriate size and in such a manner as to inhibit corrosion. They are to be arranged and supported in a manner suitable for withstanding the electro-mechanical forces due to a short circuit.

8.5 Overload and short circuit protection

8.5.1 Provision is to be made for protection against severe overloads, and electrical faults likely to result in damage to the plant.

8.5.2 The overload protection in excitation circuits should not lead to opening of the circuit.

8.6 Earth leakage detection

8.6.1 The main propulsion circuit is to be provided with means for detecting earth faults. For direct current equipments exceeding 500 V and for all alternating current equipments, aural and visual alarms are to be automatically operated on the occurrence of an earth fault, but the operation of such devices is not to interrupt the power supply. A switch may be provided to switch off the aural devices, but in such cases the visual alarm is to remain switched on to indicate that the aural device is switched off. Alternative arrangements will be specially considered.

8.6.2 If an earth connection is used for operating the detector arrangements, then in direct current systems the earth circuit is to be automatically opened in order to stop the circulation of fault current. In alternating current systems, the fault current is to be interrupted or limited to a safe value.

8.6.3 Earth leakage devices are to be arranged to function for all earth faults exceeding 5 A. In three-phase star connected alternating current generators and motors with neutral points earthed, the earth leakage device is to operate on the occurrence of an earth fault in the windings of the machine, provided that 5 per cent of the coils at the neutral end of each phase may be left unprotected by the device. In high voltage alternating current systems, where the capacitive leakage current is high, consideration will be given to increasing this figure of five per cent.

8.6.4 Excitation circuits are to be provided with lamps, voltmeters or other means to indicate continuously the state of the insulation of the excitation circuits under running conditions.

8.7 Discharge protection

8.7.1 For the protection of field windings and cables, means are to be provided for limiting the induced voltage when the field circuits are opened or, alternatively, the induced voltage, when the field circuits are opened, is to be taken as the nominal design voltage.

8.7.2 Where excitation is obtained from the auxiliary busbars, means are to be provided to limit the voltage induced at the busbars when the auxiliary circuit-breaker or the distribution circuit-breaker opens.

8.7.3 Shunt resistors which are connected across the field circuit of synchronous propulsion motors, when they are functioning as asynchronous motors, are to be suitably insulated for the voltage induced when reversing, and are to be amply rated to allow for inadvertent delay during the reversing operation.

8.8 Safety devices

8.8.1 Where separately driven direct current generators are connected electrically in series, means are to be provided to prevent reversal of the direction of rotation of any of them on the failure of the prime movers.

8.8.2 Where, on stopping or reversing the propeller, the regenerated energy transmitted by the propulsion motor is such as to cause a dangerous increase of speed in the prime mover, means are to be provided for suitably absorbing or limiting such energy.

8.8.3 Contactors and switches used for reversing the rotation of the propulsion motors are to be provided with means for forcibly opening them if they should in advertently remain closed.

8.9 Electro-magnetic couplings

8.9.1 Propulsion arrangements incorporating electro-magnetic couplings will receive special consideration.

8.10 Alarms

8.10.1 Where machines have enclosed ventilation systems, an aural alarm device is to be provided and arranged to operate if the temperature of the heated air exceeds the predetermined safe value.

8.11 Identification

8.11.1 All important circuits, instruments and apparatus are to be clearly labeled for identification.

Section 9

Crew and Passenger Emergency Safety Systems

9.1 Emergency lighting

9.1.1 For the purpose of this section emergency lighting, transitional emergency lighting and supplementary emergency lighting are hereafter referred to under the generic name 'emergency lighting'.

9.1.2 Emergency lighting is to be arranged so that a fire or other casualty in the spaces containing the emergency source of electrical power, associated transforming equipment and the emergency lighting switchboard does not render the main lighting system inoperative.

9.1.3 The level of illumination provided by the emergency lighting is to be adequate to permit safe evacuation in an emergency, having regard to the possible presence of smoke.

9.1.4 The exit(s) from every main compartment occupied by passengers or crew is to be continuously illuminated by an emergency lighting fitting.

9.1.5 Switches are not to be installed in the final sub-circuits to emergency light fittings unless the light fittings are serving normally unmanned spaces, i.e. storage-rooms, cold rooms, etc or where they are normally required to be extinguished for operational reasons (e.g. for night visibility from the navigating bridge). Where switches are fitted they are to be accessible only to ships crew with provision made to ensure that the emergency lighting is energised when such spaces are manned and/or during emergency conditions.

9.1.6 Where emergency lighting fittings are connected to dimmers, provision is to be made, upon the loss of the main lighting, to automatically restore them to their normal level of illumination.

9.1.7 Fittings are to be specially marked to indicate that they form part of the emergency lighting system.

9.2 General emergency alarm system

9.2.1 An electrically operated bell or klaxon or other equivalent warning system installed in addition to the ship's whistle or siren, for sounding the general emergency alarm signal is to comply with the requirement of this Section.

9.2.2 The system is to be capable of operation from at least the navigating bridge and except for the ship’s whistle, also from other strategic points.

9.2.3 The alarm system is to be fed by exclusive circuits, one from the main source of electrical power and one from an emergency source of electrical power with automatic change-over facilities located in, or adjacent to the main alarm signal distribution panel.

9.2.4 The alarm system is to be audible throughout all the accommodation and normal crew working spaces with all doors and accesses closed and is to have a sound pressure level, in the 1/3-octave band above the fundamental, of not less than 75dB(A) and at least 10 dB(A) above normal ambient noise levels, with the ship underway in moderate weather, when measured at the sleeping positions in the cabins and one metre from the source. An audible alarm level of 120 dB(A) is not to be exceeded in any space.

9.2.5 With the exception of bells, the alarm is to have a signal frequency between 200 Hz and 2.5 kHz.

9.2.6 Where the special alarm fitted to summon the crew from the navigation bridge, of fire control station, forms part of the ship's general alarm system, it is to be capable of being sounded independently of the alarm to the passenger spaces.

9.3 Public address system

9.3.1 Public address systems installed in accordance with Pt.6, Ch.4 are to comply with requirements of this Section.

9.3.2 Where the public address system forms part of the internal communication equipment required in an emergency it is to be fed by exclusive circuits, one from the main source of electrical power and one from an emergency source of electrical power with automatic change-over facilities located adjacent to the public address system.

9.3.3 Amplifiers are to be continuously rated for the maximum power that they are required to deliver into the system for audio and, where alarms are to be sounded through the public address system, for tone signals.

9.3.4 Loudspeakers are to be continuously rated for their proportionate share of amplifier output.

9.3.5 Amplifiers and loudspeakers are to be selected and arranged to prevent feedback and other interference.

9.3.6 Where the public address system does not form part of the internal communication equipment required in an emergency, provision is to be made, at a position adjacent to the emergency system control panel, to silence the public address system.

9.3.7 The public address system may be used for sounding the general emergency alarm and the fire alarm provided that in addition to the requirements of 9.2.

a) the emergency system is given automatic priority over any other system input;

b) there are means to automatically override any volume controls so as to ensure the specified sound pressure levels are met;

c) there are multiple amplifiers having their power supplies so arranged that a single fault will not cause the loss of more than one amplifier;

d) there are segregated cable routes to public rooms, alleyways, stairways, and control stations so arranged that any single electrical fault or a fire in any one main vertical fire zone as defined by Pt.6, Ch.3, other than the zone in which the public address control station is located, will not interfere with the sounding of the emergency alarm through the remaining system;

e) more than one device is provided for generating the sound signals for the emergency alarms;

f) short circuit protection is fitted for individual loudspeakers.

9.3.8 Where more than one alarm is to be sounded through the public address system they are to have recognizably different characteristics and additionally be arranged so that any single electrical failure which prevents the sounding of any one alarm will not affect the sounding of the remaining alarms.

Section 10

Ship Safety Systems

10.1 Watertight doors

10.1.1 The electrical power required for power-operated sliding watertight doors is to be separate from any other power circuit and supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck. The associated control, indication and alarm circuits are to be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck and for passenger ships be capable of being automatically supplied by the transitional source of emergency electrical power in the event of failure of either the main or emergency source of electrical power.

10.1.2 For passenger ships, where the source for opening and closing the watertight doors have electric motors, unless an independent temporary source of stored energy is provided, the electric motors are to be capable of being automatically supplied from the transitional source of emergency electrical power.

10.1.3 A single electrical failure in the power operating or control system of power-operated sliding watertight doors is not to result in a closed door opening or prevent the hand operation of any door.

10.1.4 Availability of the power supply is to be continuously monitored at a point in the electrical circuit adjacent to the door operating equipment. Loss of any such power supply is to activate an audible and visual alarm at the central operating console at the navigating bridge.

10.1.5 Electrical power, control, indication and alarm circuits are to be protected against fault in such a way that a failure in one door circuit will not cause a failure in any other door circuit. Short circuits or other faults in the alarm or indicator circuits of a door are not to result in a loss of power operation of the door.

Arrangements are to be such that leakage of water into the electrical equipment located below the bulkhead deck will not cause the door to open.

10.1.6 The enclosures of electrical components necessarily situated below the bulkhead deck are to provide suitable protection against the ingress of water with ratings as defined in IEC Publication 529 or an acceptable and relevant national standard, as follows :

a) Electrical motors, associated circuits and control components, protected to IPX7 standard.

b) Door position indicators and associated circuit components protected to IPX8 standard, where the water pressure testing of the enclosures is to be based on the pressure that may occur at the location of the component during flooding for a period of 36 hours.

c) Door movement warning signals, protected to IPX6 standard.

10.1.7 Watertight door electrical controls including their electric cables are to be kept as close as is practicable to the bulkhead in which the doors are fitted and so arranged that the likelihood of them being involved in any damage which the ship may sustain is minimized.

10.1.8 An audible alarm, distinct from any other alarm in the area, is to sound whenever the door is closed remotely by power and sound for at least five seconds but no more than ten seconds before the door begins to move and is to continue sounding until the door is completely closed. The audible alarm is to be supplemented by an intermittent visual signal at the door in passenger areas and areas where the noise level exceeds 85 dB(A).

10.1.9 A central operating console is to be fitted on the navigating bridge and is to be provided with a 'master-mode' switch having :

a) a 'local control' mode for normal use which is to allow any door to be locally opened and locally closed after use without automatic closure, and;

b) a 'doors closed' mode for emergency use which is to allow any door that is opened to be automatically closed whilst still permitting any doors to be locally opened but with automatic reclosure upon release of the local control mechanism.

10.1.10 The 'master mode' switch is to be arranged to be normally in the 'local control' mode position; be clearly marked as to its emergency function.

10.1.11 The central operating console at the navigating bridge is to be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light is to indicate a door is fully open and a green light, a door fully closed. When the door is closed remotely a red light is to indicate the intermediate position by flashing. The indicating circuit is to be independent of the control circuit for each door.

10.1.12 The arrangements are to be such that it is not possible to remotely open any door from the central operating console.

10.2 Shell doors, loading doors and other closing appliances

10.2.1 Where it is required that indicators be provided for shell doors, loading doors and other closing appliances, which are intended to ensure the watertight integrity of the ships structure in which they are located, the indicator system is to be designed on the fail-safe principle. The system is to indicate if any of the doors or closing appliances are open or are not fully closed or secured.

10.2.2 Where such doors and appliances are to be operated at sea, the requirements of 10.1 are to be complied with as far as is practicable.

10.2.3 The electrical power supply for the indicator system is to be independent of any electrical power supply for operating and securing the doors.

10.2.4 For the requirements of side shell doors, stern doors and bow doors, also refer to Pt.3, Ch.12, Sections 5 and 6.

Section 11

Electrical Equipment for use in Explosive Gas/Combustible Dust Atmospheres

11.1 General

11.1.1 The installation of electrical equipment in areas containing flammable gas or vapour and/or combustible dust, is to be minimized as far as is consistent with operational necessity and the provision of lighting, monitoring, alarm or control facilities enhancing the overall safety of the ship.

11.1.2 Combustible dust is defined as finely divided solid particles, 500 μm or less in nominal size, which may be suspended in air, may settle out of the atmosphere under their own weight, may burn or glow in air and may form explosive mixtures with air at atmospheric pressure and normal temperatures. (See IEC 60079-0).

Note : Examples of cargoes that can generate combustible dust with explosive hazard as per the IMSBC Code are:

Brown coal briquettes, sulphur UN 1350, iron oxide-spent or iron sponge-spent UN1376, wood pellets, peat moss, pitch prill etc.

11.2 Selection of equipment

11.2.1 When apparatus is to be installed in areas where an explosive gas atmosphere may be present, unless permitted otherwise by 11.2.2, it is to be of a 'safe type', as listed below, certified or approved by a competent authority for the gases encountered. The construction and type testing is to be in accordance with IEC Publication 79: Electrical Equipment for Explosive Gas Atmospheres or an acceptable and relevant national standard.

Intrinsically safe	Ex 'i'
Increased safety	Ex 'e'
Flameproof	Ex 'd'
Pressurized enclosure	Ex 'p'
Power filled	Ex 'q'
Encapsulated	Ex 'm'.

11.2.2 Consideration may be given to the use of equipment of the following types:

a) equipment such as control panels, protected by purging and pressurisation and capable of being verified by inspection as meeting the requirements of IEC 60079-2;

b) simple non-energy-storing apparatus having negligible surface temperature rise in normal operation, such as limit switches, strain gauges, etc., incorporated in intrinsically-safe circuits;

c) radio aerials having robust construction, meeting the relevant requirements of IEC 60079-15;

d) electrical apparatus with type of protection 'n' or 'N' provided it is in a well ventilated area on open deck and not within 3 [m] of any flammable gas or vapour outlet.

11.2.3 Where apparatus is to be installed in areas where combustible dusts may be present in quantities sufficient to create an explosive atmosphere, it is, when practicable, to be of a type certified or approved by a competent authority for the dusts and additionally any explosive gases encountered.

11.2.4 Electrical equipment for use in combustible dust atmospheres is to be so designed and installed as to minimize the accumulation of dust which may interfere with the safe dissipation of heat from the enclosure.

11.2.5 Where equipment certified for combustible dust, is not available, consideration will be given to the use of apparatus complying as a minimum, with the following requirements provided no explosive gases will be present:

a) the enclosure is to be at least dust protected (IP5X) having, when type tested, an ingress of fine dust within the enclosure not exceeding 10 g per [m^3] of free air space, and

b) the surface temperature of the apparatus, under the most onerous combination of normal operating conditions, but in the absence of a dust layer, is to be at least 10°C below the auto-ignition temperature of the dusts encountered, or

c) the equipment is to be certified intrinsically-safe having a temperature classification ensuring compliance with (b), or

d) pressurized and operated in accordance with procedures ensuring, prior to its reenergisation, the absence of dust within the enclosure following loss of pressurisation and consequent shutdown, and having surface temperature complying with (b), or

e) simple apparatus included in intrinsically-safe circuits or radio aerials, complying with 11.2.2 (b) or (c) respectively.

11.3 Installation of electrical equipment and cabling

11.3.1 The method of installation and application of safe type equipment is to be in accordance with IEC 79-14, or the national code of practice relevant to the standard to which the equipment has been certified. Any special requirements laid down by the equipment certification documentation are also to be observed. The ambient temperature range for which the apparatus is certified, is to be taken to be -20°C to 40°C, unless otherwise stated, and account is to be taken of this when assessing the suitability of the equipment for the auto-ignition temperature of the gases and dusts encountered.

11.3.2 All switches and protective devices from which equipment located in dangerous zones or spaces is supplied are to interrupt all poles or phases and, where practicable are to be located in non-hazardous zone or space. Such equipment, switches and protective devices are to be suitably labeled for identification purposes.

11.3.3 Metal coverings of cables installed in dangerous zones or spaces are to be effectively earthed at both ends.

11.3.4 Cables associated with intrinsically-safe circuits are to be used only for such circuits. They are to be physically separated from cables associated with non-intrinsically-safe circuits, e.g. neither installed in the same protective casing nor secured by the same fixing clip.

11.3.5 Where there is risk of intermittent contact between armour and exposed metalwork, non-metallic impervious sheath is to be applied over metallic armour of cable.

11.4 Dangerous zones and spaces

11.4.1 Dangerous zones or spaces and sources of hazard for ships intended for the carriage in bulk of oil, liquefied gases and other hazardous liquids, and the requirements for ships carrying vehicles with fuel in their tanks, are defined in 11.9 to 11.12. The following principles are to apply in general, and where any specific arrangement does not fall into any of the categories covered by 11.9 to 11.12.

11.4.2 A dangerous zone or space may arise from the presence of any of the following:

a) spaces or tanks containing either

    i) flammable liquid having a flashpoint (closed-cup test), not exceeding 60°C;

    ii) flammable liquid having a flashpoint exceeding 60°C, heated or raised by ambient conditions to a temperature within 15°C of its flashpoint;

    iii) flammable gas.

b) piping systems or equipment containing fluid defined by (a) and having flanged joints or glands or other openings through which leakage of fluid may occur under normal operating conditions;

c) spaces containing solids, such as coal or grain, liable to release flammable gas and/or combustible dust;

d) piping systems or equipment associated with processes (such as battery charging or electrochlorination) generating flammable gas as a by-product and having openings from which the gas may escape under normal operating conditions;

e) piping system or equivalent containing flammable liquids not defined by (a), having flanged joints, glands or other openings through which leakage of fluid in the form of a mist or fine spray may occur under normal operating conditions.

11.4.3 The following zones or spaces are regarded as dangerous:

a) the interiors of those spaces or tanks defined by 11.4.2(a) and (c);

b) spaces separated by a single bulkhead or deck from a cargo defined by 11.4.2(a);

c) enclosed or semi-enclosed spaces containing pipework or equipment defined by 11.4.2(b) and (d);

d) enclosed or semi-enclosed spaces with direct opening into a dangerous space;

e) zones within a 3 [m] radius of ventilation inlets or outlets, hatches or doorways or other openings into dangerous spaces, and within 3 [m] of the ventilation outlets of spaces regarded by 11.5 as open areas and which contain the pipework or equipment defined by 11.4.2(b); space where the hazard results from flammable gas or vapour having a density relative to that of air of more than 0.5, the dangerous zone is considered to extend vertically downward to solid deck, or for a distance of 9 [m], whichever is the lesser;

f) zones within a 3 [m] radius of flanged joints, or glands or other openings defined by 11.4.2(b); in the case of gas or vapour having a relative density of more than 0.5, the dangerous zone is considered to extend vertically downwards as described under (e);

g) zones within a 1.5 [m] radius of the ventilation outlets of spaces regarded as open areas containing items defined under 11.4.2(d);

h) zones within a 1.5 [m] radius of flanged joints, or glands or other openings defined by 11.4.2(d) and (e);

i) zones within a 3 [m] radius of bunds or barriers intended to contain spillage of liquids defined by 11.4.2(a).

11.5 Semi-enclosed spaces

11.5.1 Semi-enclosed spaces are considered to be spaces limited by decks and/or bulkheads in such a manner that the natural conditions of ventilation are sensibly different from those obtained on open deck.

11.6 Ventilation

11.6.1 Where an enclosed or semi-enclosed space is provided with mechanical ventilation ensuring at least 12 air changes/hour, and leaving no areas of stagnant air, it may be regarded in consideration of dangerous zones, as an open area.

11.6.2 Where the rate of ventilation air flow, in relation to the maximum rate of release of flammable substances reasonably to be expected under normal conditions, is sufficient to prevent the concentration of flammable substances approaching their lower explosive limit, consideration may be given to regarding as non-dangerous, the space, ventilation and other openings into it, and the zone around the equipment contained within.

11.7 Pressurisation

11.7.1 A space having access to a dangerous space or zone as defined under 11.4.3(c) to (i) may be regarded as non-dangerous if fulfilling all the following conditions:

a) access is by means of an air-lock, having gas-tight steel doors, the inner of which as a minimum, is self-closing without any hold-back arrangement;

b) it is maintained at an overpressure relative to the external hazardous area by ventilation from a non-dangerous area;

c) the relative air pressure within the space is continuously monitored and, so arranged, that in the event of loss of overpressure an alarm is given and the electrical supply to all equipment not of a safe type is automatically disconnected. Where the shut-down of equipment could introduce a hazard, an alarm may be given, in lieu of shutdown, upon loss of overpressure, and a means of disconnection of non-safe type electrical equipment, capable of being controlled from a manned station, provided in conjunction with an agreed operational procedure; where the means of disconnection is located within the space then it is to be effected by equipment of a safe type;

d) any electrical equipment required to operate upon loss of overpressure, lighting fittings and equipment within the air-lock, is to be of a safe type;

e) means are to be provided to prevent electrical equipment other than of a safe type, being energized until the atmosphere within the space is made safe, by air renewal of at least 10 times the capacity of the space.

11.8 Cable and cable installation

11.8.1 Electric cables are not to be installed in dangerous zones or spaces, except where specifically permitted by 11.9. to 11.11 or when associated with intrinsically-safe circuits.

11.8.2 In addition to other requirements in this chapter, cables in dangerous zones or spaces, or which may be exposed to cargo oil, oil vapour or gas, are to be either:

a) mineral insulated with copper sheath, or

b) armoured or braided (for mechanical protection and earth detection) with non-metallic impervious sheath.

11.9 Requirements for tankers intended for the carriage in bulk of oil cargoes having a flash point not exceeding 60°C (closed cup test)

11.9.1 The following requirements define the electrical equipment permitted within dangerous spaces and zones and are in addition to the requirements of 11.1 to 11.8.

11.9.2 The requirements for cargo tanks also apply to cargo slops tanks.

11.9.3 The relevant gas group and temperature class for safe type equipment in the defined locations are IIA T3.

11.9.4 Where intrinsically-safe equipment is required, consideration will be given to the use of simple apparatus incorporated in intrinsically-safe circuits, as defined in 11.2.2(b).

11.9.5 Cargo tanks: intrinsically-safe equipment of category 'ia':

11.9.6 Cofferdams adjoining cargo tanks

a) intrinsically-safe equipment of category 'ia';

b) electric depth-sounding devices hermetically enclosed, located clear of the cargo tank bulkhead, with cables installed in heavy gauge steel pipes with gastight joints up to the main deck;

c) cables for impressed current cathodic protection systems (for external hull protection only) installed in heavy gauge steel pipes with gas tight joints up to the upper deck;

d) through runs of cables, installed in heavy gauge steel pipes with gas tight joints.

11.9.7 Cargo pump rooms:

a) intrinsically-safe equipment;

b) electrical equipment as defined in 11.9.6(b) and (c);

c) flameproof lighting fittings (symbol d);

d) pressurised lighting fittings (symbol p) of either the air driven type, of pressurised from an external source of protective gas and arranged to be de-energised automatically on loss of pressurization;

e) gas detector heads having sinter-type flametrap protection, included within an intrinsically-safe circuit, the gas detector system is to be certified;

f) general alarm sounders of flameproof type, without internal sparking contacts;

g) through runs of cables, confined to pump room entrances only, installed in heavy gauge steel pipes with gas tight joints.

11.9.8 Spaces under cargo tanks (e.g. duct keels): Electrical equipment as defined in 11.9.6(a) and (b) and 11.9.7(c) to (f).

11.9.9 Enclosed or semi-enclosed spaces immediately above cargo tanks or having bulkheads immediately above and in line with cargo tank bulkheads, compartments for cargo hoses, spaces other than cofferdams adjoining and below the top of a cargo tanks, e.g. trunk, passageways and holds:

a) intrinsically-safe equipment, this is to be of category 'ia' where the spaces or compartments are not mechanically ventilated;

b) safe type lighting fittings;

c) through runs of cable;

d) general alarm sounders as defined by 11.9.7(f).

11.9.10 Electrical equipment or cables are not normally to be installed in hazardous areas. Where essential for operational purposes, electrical equipment may be installed in accordance with IEC 60092-502: Electrical installations in ships - Tankers - Special features as per the following area classification:

11.9.10.1 Areas on open deck adjoining cargo openings (refer Part 5, Chapter 2, Clause 8.1.4.a) permitting flow of small volumes of vapour or gas mixtures:

a) Zone 1- Areas on open deck, or semi-enclosed spaces on open deck within 3 [m] of any cargo oil tank outlet or vapour outlet (e.g. cargo tank or cofferdam hatch; sight port; tank cleaning opening; ullage opening;

sounding pipe cargo pump room entrance and ventilation intakes and exhausts) which permit the flow of small volumes of vapour or gas mixtures caused by thermal variation as given in IEC 60092-502 para 4.2.2.7.

b) Zone 2 - Areas within 2 [m] beyond the zone 1 above.(note: 1.5 [m] given in IEC 60092-502 para 4.2.3.1).

11.9.10.2 Areas on open deck adjoining cargo openings (refer Part 5, Chapter 2, Clause 8.1.4.b) permitting flow of large volumes of vapour or gas mixtures:

Zone 1- Areas on open deck, or semi-enclosed spaces on open deck, within a vertical cylinder of unlimited height and 6m radius centered upon the centre of the outlet, and within a hemisphere of 6m radius below the outlet which permit the flow of large volumes of vapour or gas mixtures during loading/discharging/ballasting as given in IEC 60092-502 para 4.2.2.8. (e.g. pressure/vacuum valve, high velocity vents, mast riser).

a) Zone 2- Areas within 4m beyond the zone 1 above as given in IEC 60092-502 para 4.2.3.2.

11.9.10.3 Areas on open deck over all cargo tanks (including all ballast tanks within the cargo tank area) to the full width of the vessel, plus 3 [m] forward and 3 [m] aft of the cargo tank area or any spillage barrier installed aft of the cargo tanks area, up to a height of 2.4 [m] above the deck

a) Zone 1- Where structures are restricting the natural ventilation as given in IEC 60092-502 para 4.2.2.11.

b) Zone 2- Where unrestricted natural ventilation is guaranteed as given in IEC 60092-502 para 4.2.3.5.

11.9.11 Spaces below the level of, and having direct openings onto, the main deck, but outside the dangerous zone previously described:

a) safe type equipment;

b) through runs of cable.

11.9.12 Mechanically ventilated or pressurized spaces:

a) where a space of the type defined by 11.9.13 is provided with a self closing door for the opening onto the main deck and has mechanical ventilation, the air intake for which is remote from any dangerous space or zone, non-safe equipment is permitted within the space;

b) where a space opening into a dangerous into a dangerous zone or space is provided with an airlock, is separated from the cargo by at least two gastight bulkhead, and is pressurized in accordance with 11.7, non-safe type equipment is permitted within the space.

11.9.13 Electrical installations in enclosed or semi-enclosed spaces having a direct opening into any dangerous space or zone are to comply with the requirements for the space or zone to which the opening leads.

11.10 Requirements for ships for the carriage of liquefied gases in bulk

11.10.1 See Pt.5 for relevant Rules for Ships for Liquefied Gases.

11.11 Requirements for ships intended for the carriage in bulk of other flammable liquid cargoes

11.11.1 See Pt.5 for relevant Rules for Ships for Liquid Chemicals.

11.12 Special requirements for ships with spaces for carrying vehicles with fuel in their tanks, for their own propulsion

11.12.1 Passenger ships with special category spaces above the bulkhead deck for carrying vehicles:

a) electrical equipment fitted within a height of 45 [cm] above the vehicle deck, or any platform on which vehicles are carried, or within the exhaust ventilation trunking of the special category space, is to be of a safe type;

b) electrical equipment situated elsewhere within the space is to have an enclosure of ingress protection rating of at least IP55. (See IEC Publication 529: Classification of Degrees of Protection Provided by Enclosures), if not of a safe type.

11.12.2 Passenger ships with special category spaces below the bulkhead deck for carrying vehicles: electrical equipment fitted within the space and within the space's exhaust ventilation trunking, is to be of certified safe type.

11.12.3 Passenger ship with cargo spaces, other than special category spaces, for carrying vehicles:

a) electrical equipment within such a cargo space, or within the space's exhaust ventilation trunking, is to be of a safe type;

b) all electrical circuits terminating in the cargo space are to be provided with multi-pole linked isolating switches located outside the cargo hold. Provision is to be made for locking in the off position. This does not apply to safety circuits such as those for fire, smoke or gas detection.

11.12.4 Cargo ships with spaces for carrying vehicles:

a) electrical equipment fitted within a height of 45 [cm] above the vehicle deck, or within a height of 45 [cm] above the vehicle deck, or within the cargo space's exhaust ventilation trunking, and any equipment associated with safety circuits such as those for fire, smoke or gas detection, located within the cargo space, is to be of a safe type;

b) the requirements of 11.12.1(b) apply to other equipment within the space;

c) the requirements of 11.12.3(b) apply to circuits terminating in the space.

11.13 Requirements of electrical equipment allowed in paint stores and in the enclosed spaces leading to paint stores

11.13.1 Electrical equipment is to be installed in paint stores and in ventilation ducts serving such spaces only when it is essential for operational services.

Certified safe type equipment of the following type is acceptable:

a) intrinsically safe Ex 'i'

b) flameproof Ex 'd'

c) pressurised Ex 'p'

d) increased safety Ex 'e'

e) special protection Ex 's'.

Cables (through-runs or terminating cables) of armoured type or installed in metallic conduits are to be used.

11.13.2 The minimum requirements for the certified safe type equipment are as follows:

- explosion group II B

- temperature class T3.

11.13.3 Switches, protective devices, motor control gear of electrical equipment installed in a paint store are to interrupt all poles or phases and preferably are to be located in non-hazardous space.

11.13.4 In the areas on open deck within 1 m of inlet and exhaust ventilation openings or within 3 m of exhaust mechanical ventilation outlets, the following electrical equipment may be installed:

- electrical equipment with the type of protection as permitted in paint stores or

- equipment of protection class Ex 'n' or

- appliances which do not generate arcs in service and whose surface does not reach unacceptably high temperature or

- appliances with simplified pressurised enclosures or vapour-proof enclosures (minimum class of protection IP55) whose surface does not reach unacceptably high temperature

- cables as specified in 11.13.1.

11.13.5 The enclosed spaces giving access to the paint store may be considered as non-hazardous, provided that:

- the door to the paint store is a gastight door with self-closing devices without holding back arrangements,

- the paint store is provided with an acceptable, independent, natural ventilation system ventilated from a safe area,

- warning notices are fitted adjacent to the paint store entrance stating that the store contains flammable liquids.

Note: The paint stores and inlet and exhaust ventilation ducts under 11.13.1 are classified as Zone-1 and areas on open deck under 11.13.4 as Zone 2, as defined in IEC Standard 60092-502, Electrical Installation in Ships - Part 502 : Tankers-special features.

A watertight door may be considered as being gastight.

Section 12

High Voltage Systems

12.1 Scope

12.1.1 The requirements of this Section apply to a.c. three-phase systems with nominal voltage above 1 kV and upto 15 kV.

12.1.2 The nominal voltage is the voltage between phases.

12.1.3 Where necessary for special application, higher voltages may be accepted by IRS.

12.2 High voltage and low-voltage segregation

12.2.1 Equipment with voltage above 1 kV is not to be installed in the same enclosure as low voltage equipment, unless segregation or other suitable measures are taken to ensure that access to low voltage equipment is obtained without danger.

12.3 System design

12.3.1 It is to be possible to split the main switchboard into atleast two independent sections, by means of at least one circuit breaker or other suitable disconnecting devices, each supplied by at least one generator. If two separate switchboards are provided and interconnected with cables, a circuit breaker is to be provided at each end of the cable.

12.3.2 Services which are duplicated are to be divided between the sections.

12.3.3 In a neutral earthed system, in case of earth fault the current is not to be greater than full load current of the largest generator on the switchboard or relevant switchboard section and not less than three times the minimum current required to operate any device against earth fault. It is to be assured that at least one source neutral to ground connection is available whenever the system is in the energized mode.

12.3.4 Electrical equipment in directly earthed neutral or other neutral earthed systems is to withstand the current due to a single phase fault against earth for time necessary to trip the protection device.

12.3.5 Means of disconnection are to be fitted in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance and for insulation resistance measurement.

12.3.6 All earthing impedances are to be connected to the hull. The connection to the hull is to be so arranged that any circulating currents in the earth connections do not interfere with radio, radar, communication and control equipment circuits.

12.3.7 In the divided systems with neutral earthed, connection of the neutral to the hull is to be provided for each section.

12.4 Degrees of protection

12.4.1 Each part of the electrical installation is to be provided with a degree of protection appropriate to the location, and as a minimum the requirements of IEC Publication 60092-201 are to be followed.

12.4.2 The degree of protection of enclosures of rotating electrical machines is to be at least IP23. The degree of protection of terminals is to be at least IP44.

12.4.3 For motors installed in spaces accessible to unqualified personnel, a degree of protection against approaching or contact with live or moving parts of at least IP4X is required.

12.4.4 The degree of protection of enclosures of transformers is to be at least IP23.

12.4.5 For Transformers installed in spaces accessible to unqualified personnel a degree of protection of at least IP4X is required. For transformers not contained in enclosures, see clause 12.14.1.

12.4.6 The degree of protection of metal enclosed switchgear, controlgear assemblies and static converters is to be atleast IP32. For switchgear, control gear assemblies and static converters installed in spaces accessible to unqualified personnel, a degree of protection of at least IP4X is required.

12.5 Air clearances

12.5.1 In general, for Non Type Tested equipment phase-to-phase air clearances and phase-to-earth air clearances between non-insulated parts are to be as specified in Table 12.5.1.

Table 12.5.1

Nominal Voltage [kV]	Minimum air clearance [mm]
3 - 3.3	55
6 - 6.6	90
10 - 11	120
15	160
Notes 1 Intermediate values may be accepted for nominal voltages provided that the next higher air clearance is observed. 2 In the case of smaller distances, appropriate voltage impulse test must be applied.	

12.6 Creepage distances

12.6.1 Creepage distance between live parts and between live parts and earthed metal parts are to be in accordance with IEC 60092-503 for the nominal voltage of the system the nature of the insulation material and the transient overvoltage developed by switch and fault conditions.

12.7 Protection

12.7.1 **Faults on the generator side of circuit breaker** : Protective devices are to be provided against phase-to-phase faults in the cables connecting the generators to the main switchboard and against interwinding faults within the generators. The protective devices are to trip the generator circuit breaker and to automatically de-excite the generator. In distribution systems with a neutral earthed, phase to earth faults are also to be treated as above.

12.7.2 **Faults to earth** : Any earth fault in the system is to be indicated by means of a visual and audible alarm. In low impedance or direct earthed systems, provision is to be made to automatically disconnect the faulty circuits. In high impedance earthed system, where outgoing feeders will not be isolated in case of an earth fault, insulation of the equipment is to be designed for the phase to phase voltage.

Note: Earthing factor is defined as the ratio between the phase to earth voltage of the healthy phase and the phase to phase voltage. This factor may very between $1/\sqrt{3}$ and 1.

A system is defined effectively earthed (low impedance) when this factor is lower than 0.8.

A system is defined non-effectively earthed (high impedance) when this factor is higher than 0.8.

12.7.3 **Power transformers** : Power transformers are to be provided with overload and short circuit protections. When transformers are connected in parallel, tripping of the protective devices at the primary side has to automatically trip the switch connected at the secondary side.

12.7.4 **Voltage transformers for control and instrumentation** : Voltage transformers are to be provided with overload and short circuit protections on the secondary side.

12.7.5 **Fuses** : Fuses are not to be used for overload protection.

12.7.6 **Low voltage systems** : Low voltage systems supplied through transformers from high voltage systems are to be protected against overvoltage. This may be achieved by:

i) direct earthing of the low voltage system;
ii) appropriate neutral voltage limiters;
iii) earthed screen between the primary and secondary windings of transformers.

12.8 Rotating machinery

12.8.1 **Stator windings of generators** : Generators stator windings are to have all phase ends brought out for the installation of the differential protection.

12.8.2 **Temperature detectors** : Rotating machinery is to be provided with temperature detectors in their stator windings to actuate audiovisual alarm in a normally attended position whenever the temperature exceeds the permissible limit. If embedded temperature detectors are used, means are to be provided to protect the circuit against overvoltage.

12.8.3 Tests : In addition to the tests normally required for rotating machinery, a high frequency high voltage test in accordance with IEC Publication 60034-15 is to be carried out on the individual coils in order to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

12.9 Power Transformers

12.9.1 Dry type transformers have to comply with IEC Publication 60726. Liquid cooled transformers have to comply with IEC Publication 60076. Oil immersed transformers are to be provided with the following alarms and protections:

- liquid level (Low) - alarm
- liquid temperature (High) - alarm
- liquid level (Low) - trip or load reduction
- liquid level (High) - trip or load reduction
- gas pressure relay (High) - trip.

12.10 Cables

12.10.1 Cables are to be constructed in accordance with the IEC Publication 60092-353 and 60092-354 or other equivalent Standard.

12.11 Switchgear and controlgear assemblies

12.11.1 Switchgear and controlgear assemblies are to be constructed according to the IEC Publication 62271-200 and the following additional requirements.

12.11.2 Mechanical construction : Switchgear is to be of metal - enclosed type in accordance with IEC Publication 62271-200 or of the insulation - enclosed type in accordance with the IEC Publication 62271-201.

12.11.3 Locking facilities : Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purpose, key locking of withdrawable circuit breakers and switches and fixed disconnectors is to be possible. Withdrawable circuit breakers are to be located in the service position so that there is no relative motion between fixed and moving portions.

12.11.4 Shutters : The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawable position the live contacts are automatically covered. Shutters are to be clearly marked for incoming and outgoing circuits. This may be achieved with the use of colours or labels.

12.11.5 Earthing and short-circuiting : For maintenance purposes an adequate number of earthing and short-circuiting devices are to be provided to enable circuits to be worked upon with safety.

12.11.6 Internal Arc Classification (IAC) : Switchgear and control gear assemblies are to be internal arc classified (IAC). Accessibility Type A is sufficient (IEC 62271-200; Annex AA; AA 2.2), where switchgear and control gear are accessible by authorized personnel only Accessibility Type B is required if accessible by non-authorised personnel.
Installation and location of the switchgear and control gear is to correspond with its internal arc classification and classified sides (F, L and R).

12.12 Auxiliary systems

12.12.1 Source and capacity of supply : If electrical energy and/or physical energy is required for the operation of circuit breakers and switches, a store supply of such energy is to be provided for at least two operations of all the components.
However, the tripping due to overload or short-circuit, and under-voltage is to be independent of any stored electrical energy sources. This does not preclude shunt tripping provided that alarms are activated upon lack of continuity in the release circuits and power supply failures.

12.12.2 Number of external supply sources : When external source of supply is necessary for auxiliary circuits, at least two external sources of supply are to be provided and so arranged that a failure or loss of one source will not cause the loss of more than one generator set and/or set of essential services.

Where necessary one source of supply is to be from the emergency source of electrical power for the start up from dead ship condition.

12.12.3 High voltage test : A power-frequency voltage test is to be carried out on any switchgear and controlgear assemblies.

The test procedure and voltages are to be according to the IEC Publication 62271-200, Section 7 / Routine Test.

12.13 Installation

12.13.1 **Electrical equipment** : Where equipment is not contained in an enclosure but a room forms the enclosure of the equipment, the access doors are to be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down. At the entrance of the spaces where high-voltage electrical equipment is installed, a suitable marking is to be placed which indicates danger of high voltage. As regard the high-voltage electrical equipment installed out-side above mentioned spaces, the similar marking is to be provided. An adequate, unobstructed working space is to be left in the vicinity of high voltage equipment for preventing potential severe injuries to personnel performing maintenance activities. In addition, the clearance between the switchboard and the ceiling/ deckhead above is to meet the requirements of the Internal Arc Classification according to IEC 62271-200 (see 12.11.6).

12.13.2 Cables

12.13.2.1 In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

12.13.2.2 High voltage cables are to be segregated from cables operating at different voltage ratings and from each other, in particular, they are not to be run in the same cable bunch, nor in the same ducts or pipes, or, in the same box. Where high voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between cables is not be less than the minimum air clearance for the higher voltage side in 12.6. However, high voltage cables are not to be installed on the same cable tray for the cables operating at the nominal system voltage of 1 kV and less.

12.13.2.3 High voltage cables, in general, are to be installed on carrier plating when they are provided with a continuous metallic sheath or armour which is effectively bonded to earth; otherwise they are to be installed for their entire length in metallic casings effectively bonded to earth.

12.13.2.4 Terminations in all conductors of high voltage cables are to be, as far as practicable, effectively covered with suitable insulating material. In terminal boxes, if conductors are not insulated, phases are to be separated from earth and from each other by substantial barriers of suitable insulating materials.

High voltage cables of the radial field type, i.e. having a conductive layer to control the electric field within the insulation, are to have terminations which provide electric stress control.
Terminations are to be of a type compatible with the insulation and jacket material of the cable and are to be provided with means to ground all metallic shielding components (i.e. tapes, wires etc.)

12.13.2.5 High voltage cables are to be readily identifiable by suitable marking.

12.13.2.6 Before a new high voltage cable installation or an addition to an existing installation is put into service, a voltage withstand test is to be satisfactorily carried out on each completed cable and its accessories.

The test is to be carried out after an insulation resistance test.

For cables with rated voltage (U_0/U) above 1.8/3 kV (U_m=3.6 kV) an a.c. voltage withstand test may be carried out upon advice from high voltage cable manufacturer. One of the following test methods are to be used:

a) test for 5 min with the phase-to-phase voltage of the system applied between the conductor and the metallic screen/sheath;

b) test for 24 h with the normal operating voltage of the system.

Alternatively, a d.c. test voltage equal to 4 U_0 may be applied for 15 minutes:

For cables with rated voltage (U_0/U) up to 1.8/3 kV (Um=3.6 kV) a d.c. voltage equal to 4 U_0 is to be applied for 15 minutes.

After completion of the test, the conductors are to be connected to earth for a sufficient period in order to remove any trapped electric charge.

An insulation resistance test is then to be repeated.

Section 13

Trials

13.1 General

13.1.1 Before a new installation, or any alteration or addition to an existing installation, is put into service the tests and trials specified in this Section are to be carried out. These tests and trials are intended to demonstrate the general condition of the installation at the time of completion. They are in addition to any acceptance tests which may have been carried out at the manufacturer's works.

13.2 Insulation resistance measurement

13.2.1 Insulation resistance is to be measured using a self-contained instrument such as a direct reading ohm-meter of the generator type applying a voltage of at least 500 V. Where a circuit incorporates capacitors of more than 2mF total capacitance, a constant-voltage type instrument is to be used to ensure accurate test readings.

13.2.2 Power and light circuits : The insulation resistance between all insulated poles and earth and, where practicable, between poles, is to be at least 1MΩ. The installation may be subdivided and appliances may be disconnected if initial tests produce results less than this figure.

13.2.3 Internal communication circuits : Circuits operating at 55 V and above are to have an insulation resistance between conductors and between each conductor and earth of at least 1 MΩ. Circuits operating at less than 55 V are to have an insulation resistance of at least 0.33 MΩ.

13.2.4 Switchboards, Section boards and distribution boards : The insulation resistance is to be at least 1 MΩ when measured between each busbar and earth and between busbars. This test may be made with all circuit-breakers and switches open, all fuse links for pilot lamps, earth fault-indicating lamps, voltmeters, etc., removed and voltage coils temporarily disconnected, where otherwise damage may result.

13.2.5 Generators and motors : The insulation resistance of generators and motors, in normal working condition and with all parts in place, is to be measured and recorded. The test should be carried out with the machine hot, if possible. The insulation resistance of generator and motor cables, field windings and control gear is to be at least 1 MΩ.

13.3 Earth continuity

13.3.1 Tests are to be made to verify that all earth continuity conductors are effective and that the bonding and earthing of metallic conduit and/or sheathing of cables is effective.

13.4 Performance

13.4.1 It is to be established that the provisions of the Rules have been complied with respect to the criteria mentioned in this sub-section.

13.4.2 Temperatures of joints, connections, circuit-breakers and fuses.

13.4.3 The operation of engine governors, synchronising aids and devices, overspeed trips, reverse-current, reverse-power, over-current and under-voltage trips and other safety devices.

13.4.4 Efficient lubrication, absence of vibration or abnormal noises and satisfactory alignment/ holding down arrangements.

13.4.5 Satisfactory commutation, excitation and performance of each generator throughout a run at full rated load.

13.4.6 Voltage regulation of every generator when full rated load is suddenly thrown off.

13.4.7 For alternating current and direct current generators, satisfactory parallel operation and [kW] load sharing of all generators capable of being operated in parallel at all loads up to normal working load. For alternating current generators satisfactory parallel operation and kVA load sharing of all generators capable of being operated in parallel at all loads up to normal working load.

13.4.8 All essential motors and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously, for a sufficient length of time to demonstrate that they are satisfactory.

13.4.9 Normal and emergency lighting, heating and various appliances (galley, pantry etc.) and corresponding electrical circuits are to be tested, as far as practicable, under normal working conditions.

13.4.10 Internal communication systems are to be checked to demonstrate their suitable and specified functioning. Particular attention is to be given to engine order telegraphs, docking telegraphs, helm indicators, fire detection and alarm systems, emergency alarms, morse signal lamp, navigation light indicator panel and telephones.

13.4.11 Operation of the emergency source of power is to be checked. The working of any apparatus intended to be fed by this source is to be checked as well as automatic change-over switches, if any.

13.4.12 Propulsion equipment is to be tested under working conditions and operated in the presence of the Surveyors and to their satisfaction. The equipment is to have sufficient power for going astern to secure proper control of the unit in all normal circumstances. In passenger ships the ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, under normal maneuvering conditions, and so bring the ship to rest from maximum ahead service speed, is to be demonstrated at the sea trial.

13.5 Voltage drop

13.5.1 Voltage drop is to be measured, where necessary, to verify that this is not excessive.

End of Chapter

Chapter 10

Requirements for Fusion Welding

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter apply to the welding of pressure vessels, pressure pipes and the welded structures of machinery.

1.1.2 The term 'fusion weld', for the purpose of these requirements, is applicable to welded joints made by manual, semi-automatic or automatic electric arc welding processes. Special consideration will be given to the proposed use of other fusion welding processes.

1.2.General requirements for welding plant and welding quality

1.2.1 The welding plant and equipment are to be installed under cover and so arranged that all welding is carried out in positions free from draughts and adverse weather conditions.

1.2.2 In the first instance, and before work is commenced, the Surveyors are to be satisfied that the required quality of welding is attainable with the proposed welding plant, equipment and procedures.

1.2.3 The welding plant and equipment are to be maintained in an efficient working condition.

1.2.4 The procedures are to include the regular systematic supervision of all welding, and the welders are to be subjected by the works' supervisors to periodic tests for quality of workmanship. Records of these tests are to be kept and are to be available for inspection by the Surveyors.

1.2.5 All welding is to be to the satisfaction of the Surveyors.

Section 2

Fusion Welded Pressure Vessels

2.1 Manufacture of Class 1 and Class 2 fusion welded pressure vessels

2.1.1 Fusion welded pressure vessels constructed to Class 1 and Class 2 requirements will be accepted only if manufactured by firms equipped and competent to undertake high quality welding. In order that firms may be approved for this purpose, it will be necessary for the Surveyors to visit the works for the purpose of inspecting the welding plant, equipment and procedures and to arrange for carrying out preliminary tests as stated in 2.3.

2.1.2 In the case of Class 1 approval, arrangements are to be made for the survey during construction and testing of a full size welded pressure vessel.

2.1.3 The welding plant and equipment are to be suitable for undertaking work of the standard required for Class 1 and Class 2.

2.1.4 The works are to have an efficient testing laboratory, suitably equipped to carry out tensile, bend and impact tests, the x-ray examination of pressure vessels, and the metallographic examination of welds. The works are also to be equipped with a suitable heat treating furnace with satisfactory means of temperature control.

2.1.5 Alternative arrangements which, in the opinion of the Surveyors, ensure an equally high standard of quality control may be submitted for consideration.

2.1.6 On completion of inspection and tests, the Surveyor's report, including the results of the preliminary tests and also, for Class 1 approval, the results of the tests on the pressure vessel, as required by 2.1.2, is to be submitted for the consideration of IRS. The report should also include the radiographs and particulars of any fusion welded pressure vessels previously constructed at these works.

2.2 Manufacture of Class 3 fusion welded pressure vessels

2.2.1 Class 3 pressure vessels will be accepted if constructed by firms whose works are equipped to undertake the welding of pressure vessels of this Class. Preliminary tests would require to be carried out as stated in 2.4.

2.3 Preliminary tests for Class 1 and Class 2 fusion welded pressure vessels

2.3.1 Preliminary tests to demonstrate the quality of welding are to be carried out by the firm under supervision of the Surveyors. The test requirements will be based on the types of steels and on the welding process to be used. For approval purposes, the types of rolled steel plates specified in Pt.2, Ch.3 are grouped as follows :

Group 1 : Carbon and carbon-manganese steels - specified minimum tensile strength not exceeding 500 [N/mm^2];

Group 2 : Carbon and carbon-manganese steels - Specified minimum tensile strength 500-520 [N/mm^2];

Group 3 : Alloy steels.

2.3.2 The maximum plate thickness which will be approved in pressure vessel construction will depend on the thickness of the test plates used in the preliminary tests; the test plates are, however, to be at least 20 [mm] thick.

2.3.3 The test plates and the pressure vessel, mentioned in 2.1.2, are to be representative as regards materials and approximate shell thickness of the production vessels for which approval is desired.

2.3.4 The welded seams of the test plates are to be radiographed, and the Surveyors are to select portions of the test plates containing the welded joint from which specimens are to be provided for the following tests:

a) Tensile;

b) Bend;

c) Hardness;

d) Impact - For Class 1 application and for steels in Groups 2 and 3;

e) Fatigue - For Class 1 application and for steels in Groups 2 and 3;

f) Micrographs, at 100 and 300 magnifications, of weld center, fusion zone and parent plate, for Class 1 application and for steels in Group 2 and 3;

g) Macrograph of full section weld;

h) Chemical analysis of deposited weld metal;

i) Chemical analysis of test plates.

2.3.5 Where the welding is carried out by an established and approved process, the fatigue tests and micrographs in 2.3.4(e) and (f) will not, in general, be required. Furthermore, as an alternative to 2.3.4(i), a guaranteed analysis obtained from the steelmaker will be accepted.

2.3.6 If a firm intends to manufacture pressure vessels either of a different group of steel or by means of a different welding process from that used in the preliminary tests on which the original approval was based, further tests will be required to cover the proposed welding procedure. In such cases full details of the material, plate thickness and welding process proposed are to be submitted for consideration, when the requirements for further preliminary tests will be indicated.

2.4 Preliminary tests for Class 3 fusion welded pressure vessels

2.4.1 Preliminary tests to demonstrate the quality of welding are to be carried out by the firm under the supervision of the Surveyors. The test requirements will be based on the welding process used, but are to be similar to those described in 2.4.2 to 2.4.6.

2.4.2 Two test assemblies, of sufficient dimensions to prepare test specimens, as required by 2.4.3, are to be prepared using plates of thickness representative of the thickness of the pressure vessels to be manufactured. Alternatively, one test assembly may be prepared to provide all the test specimens required by 2.4.3 and for retest purposes. Test assemblies need not be prepared for circumferential seams, except in cases where the vessel has only circumferential seams or where the process for welding the circumferential joints is significantly different from that used for longitudinal joints.

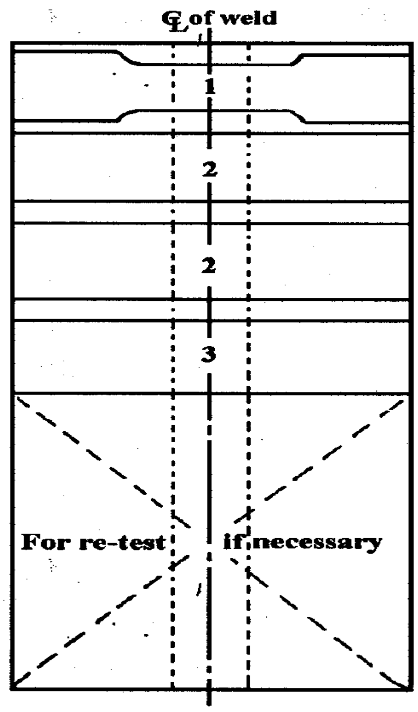


Fig. 2.4.1 : Test sample

2.4.3 Test specimens, as shown in Fig.2.4.1, are to be tested as follows :

a) Specimen No. 1 :- Tensile test for joint. The shape and preparation of the specimen are to conform to the requirements of 2.5.12. The tensile strength obtained is to be not less than the minimum specified tensile strength for the plate material;

b) Specimen No. 2 :- Transverse bend test. The shape and preparation of the specimen and procedure for testing are to comply with the requirements of 2.5.11;

c) Specimen No. 3 :- Nicked bend test. The specimen is to have a slot cut into each side on the centreline of the weld and perpendicular to the plate surface. The specimen is then to be broken in the weld, and the fracture is to reveal a sound homogeneous weld, substantially free from slag inclusions, porosity and coarse crystalline form.

2.4.4 If any of the tests fail, further two re-test specimens are to be prepared and tested. Should any of these two further re-tests also fail, the reasons for the failure are to be investigated and the results are to be submitted to IRS for review.

2.4.5 Where two test assemblies have been prepared, one re-test is to be taken from each test assembly.

2.4.6 If both the re-test values are satisfactory, the re-test values may be accepted.

2.5 Routine tests for Class 1 and Class 2 fusion welded pressure vessels

2.5.1 Two test plates, each of sufficient dimensions to provide one complete set of specimens required by 2.5.9 are to be prepared for each pressure vessel. They are to be

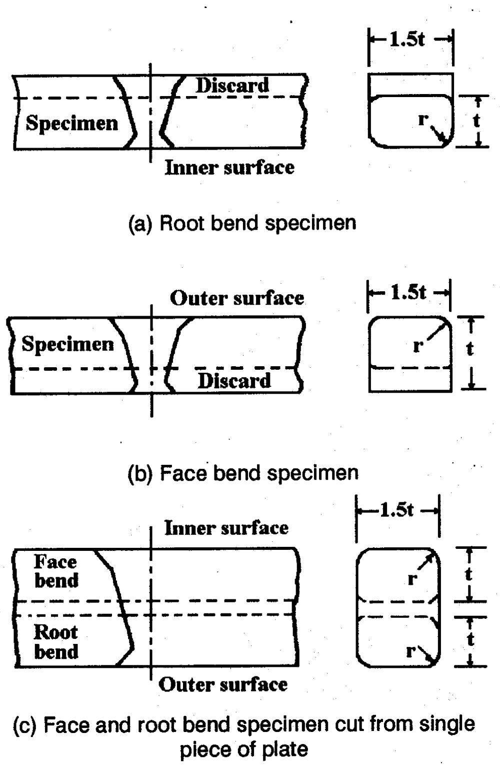


Fig. 2.5.3 : Bend test specimen

attached to the shell plate in such a manner that the edges to be welded are a continuation and simulation of the corresponding edges of the longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint.

2.5.2 As an alternative to 2.5.1, one test plate may be prepared to provide all the test specimens required by 2.5.9 and for re-test purposes.

2.5.3 Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, or where the process for welding the circumferential joints is significantly different from that used for the longitudinal joints; in which case one test plate is to be prepared having a welded joint which so far as possible is a simulation of the circumferential seams. The test plate is to provide all the test specimens required by 2.5.9 and for re-test purposes. Where a number of similar vessels are made at the same time, it will suffice if, test plates are provided for each 30 [m] of circumferential welded seam.

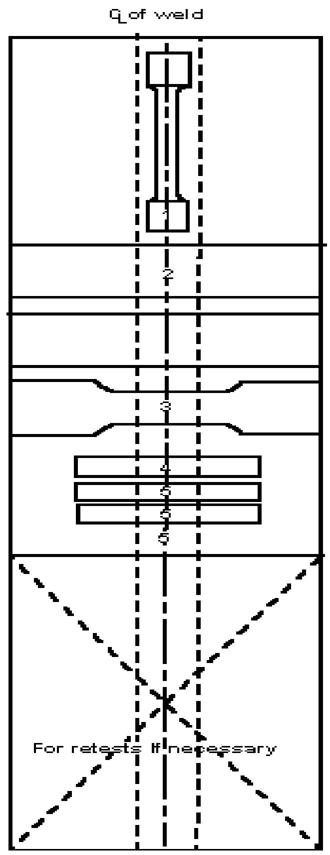


Fig.2.5.1 : Test specimen

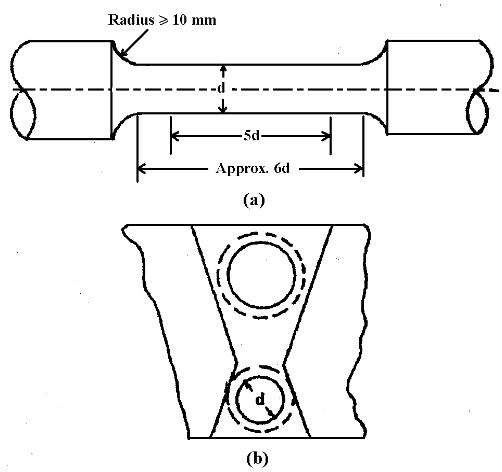


Fig. 2.5.2 : All weld test specimen

2.5.4 The test plates are to be cut from the shell plate or plates forming the appropriate seam, and before being detached are to be stamped by the Surveyor.

2.5.5 Where there is insufficient material available on the shell plates for the provision of test plates, acceptance may be given to test plates cut from another plate, provided that this plate is from the same cast and in the same heat treatment condition.

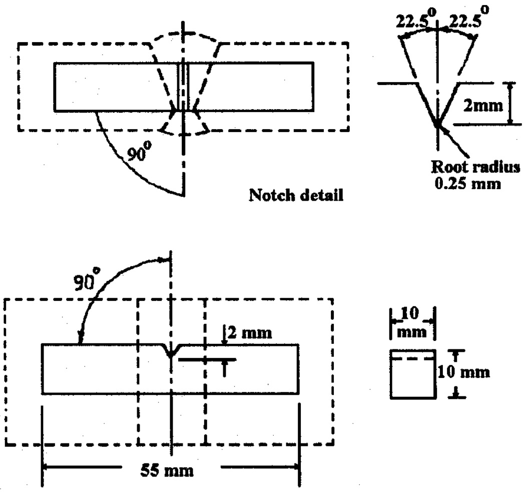


Fig. 2.5.5 : Impact test specimens

2.5.6 The thickness of test plates is to be the same as that of the pressure vessel.

2.5.7 Test plates are to be so supported, during welding, that warping is reduced to a minimum.

2.5.8 The test plates are to be straightened before being subjected to heat treatment, and for this purpose the test plates may be heated to a temperature below that required for the final heat treatment.

2.5.9 One set of test specimens is to be cut from the test plates as shown in Fig.2.5.1. The results of the tests are to comply with the requirements detailed in 2.5.10 to 2.5.14.

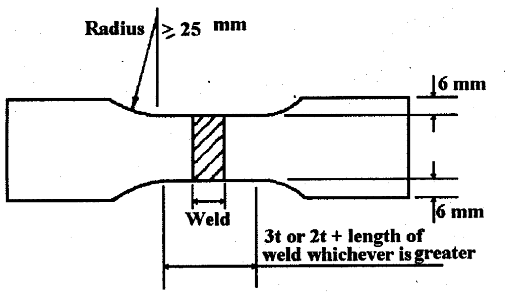


Fig. 2.5.4 : Tensile test for joint

2.5.10 Specimen no. 1 : Tensile test for the weld metal - The following conditions are to be satisfied :

a) One weld metal tensile specimen is to be taken from Class 1 pressure vessels having a shell thickness not exceeding 70 [mm], and for all Class 2 pressure vessels. Where the shell thickness of Class 1 pressure vessels exceeds 70 [mm], two such specimens are to be taken, one above the other;

b) The diameter of the all weld metal test specimen at the reduced parallel position is to be not less than 14 [mm], except in the case of thin plates, where the largest practicable diameter should be used. The gauge length of the specimen is to be 5 times the diameter;

c) The dimensions of the all weld metal test specimen are shown in Fig.2.5.2 (a), and their location when two specimens are used, in Fig.2.5.2 (b);

d) The tensile strength of the weld metal is not to be less than the minimum specified for the plate material and not more than 145 [N/mm2] above this value;

e) The percentage elongation, A, is to be not less than that given by :

$$A = \frac{980 - R}{21.6}$$

where R is the tensile strength [N/mm^2]. In addition, this elongation is to be not less than 80 per cent of the equivalent minimum elongation specified for the plate.

2.5.11 Specimen no. 2 :- Transverse bend test. The following conditions are to be satisfied :

a) Two bend test specimens of rectangular section are to be cut from the test plate transversely to the weld, one to be bent with the outer surface of the weld in tension, and the other with the inner surface in tension;

b) The specimens are to have a width equal to 1.5 times the thickness of the specimen, and the mid-portion is to coincide with the centreline of the weld. The edges are to be rounded to a radius, r, not exceeding 10 per cent of the thickness;

c) Where the plate thickness does not exceed 25 [mm], the thickness of the specimens is to be the full thickness of the plate. Where the plate thickness exceeds 25 [mm], the specimens, in all cases, are to have a thickness of 25 [mm] and are to be prepared by discarding metal from the surfaces which will be in compression when the test is applied. See Fig.2.5.3 (a) and (b);

d) Where the thickness of the plate permits, the bend specimens may be prepared as shown in Fig.2.5.3 (c);

e) For each specimen the weld reinforcement is to be removed by grinding or machining so that the outer and inner surfaces of the weld are flush with the surface of the plate;

f) The specimen is to be mounted on roller supports with the centre of the weld midway between the supports. A former, with its axis perpendicular to the specimen, is to bend the specimen by pushing it through the clear space between the supports. The diameter of the former and the clear space between the supports will depend upon thickness of the specimens, and these dimensions are shown in the following table in terms of the thickness, t, of the specimen;

Minimum specified tensile strength of plate [N/mm^2]	Diameter of former	Clear space between supports
< 460	2t	4.2t
≥ 460 < 510	3t	5.2t
≥ 510 < 620	4t	6.2t

g) After bending, there is to be no crack or defect exceeding 1.5 [mm] measured across the specimen or 3 [mm] measured along the specimen. Premature failure at the edges of the specimen will not lead to rejection.

2.5.12 Specimen no. 3 : Tensile test for joint. The following conditions are to be satisfied :

a) One reduced section tensile test specimen is to be cut transversely to the weld or, in the thick plate, as many tensile test specimens as may be necessary to investigate the tensile strength throughout the whole thickness of the joint;
The weld reinforcement is to be removed by grinding or machining so that the outer and inner surfaces of the weld are flush with the surface of the plate. The dimensions of the reduced section tensile test specimens are shown in Fig.2.5.4. The width, B, at the reduced section is to be at least 25 [mm];

b) Where the plate thickness exceeds 30 [mm], the tensile test may be effected on several reduced section specimens, each with a thickness of at least 30 [mm] and a width at the effective cross-section of at least 25 [mm];

c) The tensile strength obtained is to be not less than the minimum specified tensile strength for the plate material.

2.5.13 Specimen no. 4 : Macro-specimen. The following conditions are to be satisfied :

a) Macrograph of a complete cross-section of the weld, including the heat affected zone, is to show a satisfactory penetration and fusion, and an absence of significant inclusions or other defects;

b) Should there be any doubt as to the condition of the weld as shown by macro-etching, the area concerned is to be examined by a micrograph.

2.5.14 Specimen no. 5 : Charpy V-notch impact test - Class 1 pressure vessels only

The following conditions are to be satisfied :

a) Three Charpy V-notch impact test specimens are to be cut transversely to the weld, parallel to the plate surface and at mid-plate thickness. The notch is to be cut at approximately the centre of the weld, and the axis of the notch is to be perpendicular to the surface of the plate. See Fig.2.5.5;

b) The dimensions and tolerances of the specimens are to be in accordance with Pt.2 Ch.2;

c) The average energy value obtained from the Charpy V-notch test specimen is to be not less than 27 J when the temperature of the specimen at the time of the test does not exceed 50°C;

d) Where it is proposed to use impact tests other than the Charpy V-notch type, details are to be submitted for consideration;

e) The foregoing impact test are not applicable to pressure vessels operating at low metal temperatures, and for such cases the results of the weld metal impact tests will be specially considered.

2.5.15 The test assemblies are to be heat treated in accordance with 2.10.

2.5.16 If any of the tests fail, further two re-test specimens are to be prepared and tested. Should any of these two further re-test also fail, the reasons for the failure are to be investigated and the results are to be submitted to IRS for review.

2.5.17 Where two test assemblies have been prepared, one re-test is to be taken from each test assembly.

2.5.18 If both the re-test values are satisfactory, the re-test values may be accepted.

2.6 Routine tests for Class 3 fusion welded pressure vessels

2.6.1 Routine weld tests are not required for Class 3 pressure vessels, but occasional check tests on the quality of the welding may be carried out at the discretion of the Surveyors.

2.7 Construction and workmanship

2.7.1 Cutting of plates

2.7.1.1 Plates are to be cut to size and shaped by machine flame cutting and/or machining.

2.7.1.2 Where the plate thickness does not exceed 25 [mm], cold shearing may be used provided that the sheared edge is cut back by machining or chipping for a distance of one-quarter of the plate thickness but in no case by less than 3 [mm].

2.7.1.3 All plate edges, after being cut and before further work is carried out upon them, are to be examined for laminations, and also to ensure that any sheared edges are free from cracks. Visual methods may be supplemented by other techniques at the discretion of the Surveyors.

2.7.2 Welded joints

2.7.2.1 Only full penetration butt welds are acceptable for longitudinal and circumferential main joints.

2.7.2.2 The joints are to be welded from both sides of the plates unless otherwise approved.

2.7.2.3 Details of the welded joints between dished ends and shells, flat ends and shells or rectangular headers and methods of attaching standpipes, branches, compensating plates and pads are generally to be in accordance with Fig.2.7.2.1, Fig.2.7.2.2 and Fig.2.7.2.3 respectively.

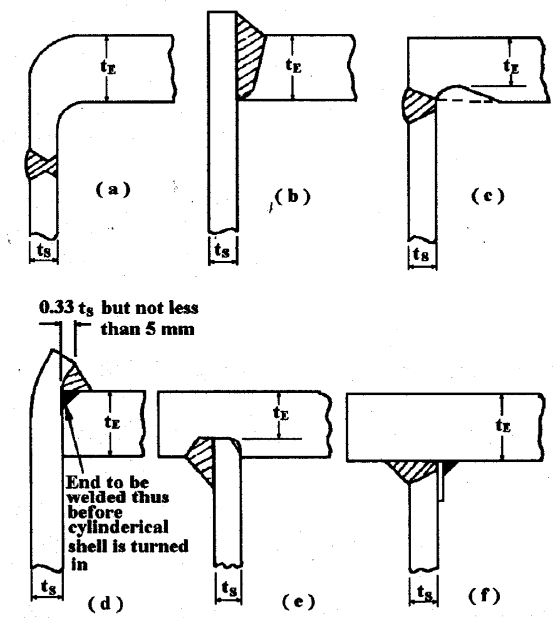


Fig. 2.7.2.2 : Typical attachments of flat ends

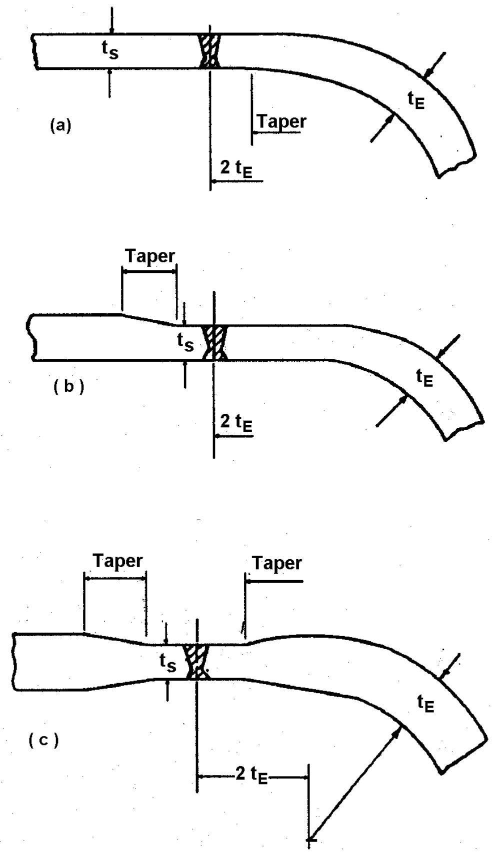
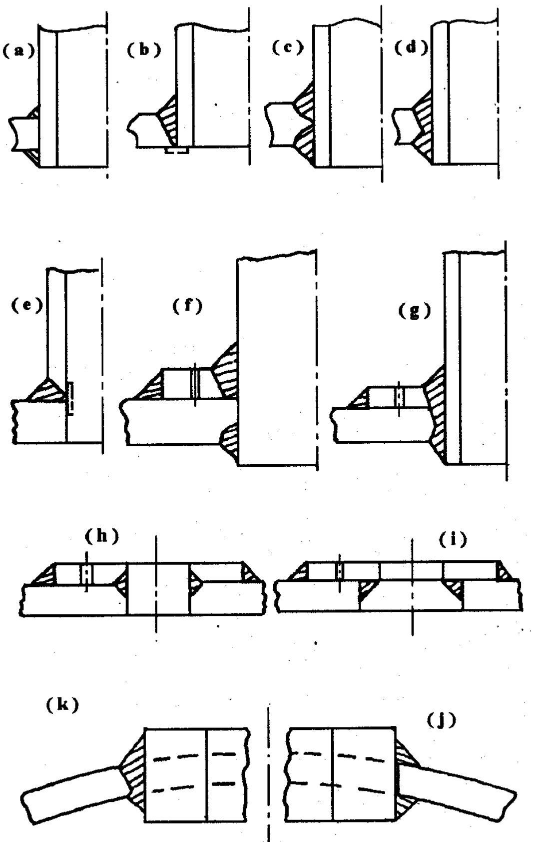


Fig.2.7.2.1 : Typical attachments of dished ends to cylindrical shells



Types (a) and (i) attachments are not to be used for openings which require to be compensated . Backing rings may be used with types (b) and (e).

Fig. 2.7.2.3 : Typical acceptable methods of attaching branches and pads

2.7.2.4 Before welding is commenced, it is to be ascertained that the plate edges are in alignment within the following limits :

a) 10 per cent of the plate thickness with a maximum of 3 [mm] for longitudinal joints;

b) 10 per cent of the plate thickness plus 1 [mm] with a maximum of 4 [mm] for circumferential joints.

2.7.2.5 If the plates are of unequal thickness, and the difference between the surfaces exceeds that given in 2.7.2.4 for the thicker plate, the thicker plate is to have a smooth taper with a slope not exceeding 15 degrees. See Fig.2.7.2.4.

2.7.2.6 Wherever practicable, the welding is to be carried out in the downhand position. In the case of circumferential joints in cylindrical shells, means are to be adopted to ensure compliance with this requirement.

2.7.2.7 Steel backing strips, if used, are to be of same nominal composition as the plates to be welded and, where practicable, are to be removed and the surface dressed smooth by grinding prior to radiography.

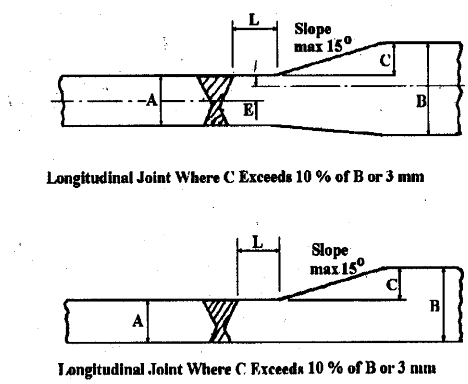


Fig. 2.7.2.4 : Attachment of plates of unequal thickness

2.7.2.8 Fillet welds are to be so made as to ensure proper fusion and penetration of the weld metal at the root of the fillet.

2.7.2.9 The arc is to be struck only on those parts of the parent metal where the weld metal is to be applied, or on the weld metal already deposited. Accidental arc strikes are to be removed by grinding followed by magnetic particle or dye penetrant testing to the satisfaction of the Surveyors.

2.7.2.10 Preheating and maintenance of minimum inter-pass temperature are to be employed where necessitated by the joint restraint, thickness of the plate or composition of the material to be welded.

2.7.3 Welding consumables

2.7.3.1 All consumables intended for use in the welding of pressure vessels are to be stored in a dry place and are to be treated in accordance with the manufacturer's instructions.

2.7.3.2 In order to ensure that the quality of welding consumables is being consistently maintained, they are to be subjected to a regular system of periodic testing and inspection.

2.7.3.3 Where routine tests are frequently carried out in respect of pressure vessels made in the normal course of production, such tests may be regarded as meeting the requirements of 2.7.3.2.

2.7.4 Forming shell sections and end plates

2.7.4.1 Plates for shell sections and end plates are to be formed to the required shape by any process that will not impair the quality of the material. Tests to demonstrate the suitability of a process may be required at the discretion of the Surveyors.

2.7.4.2 Shell plates are to be formed to the correct contour up to the extreme edges of the plates.

2.7.4.3 So far as possible, hot and cold forming is to be carried out by machine. Forming by hammering, with or without local heating, is not to be employed.

2.7.4.4 All plates which have been hot formed or locally heated for forming are to be normalized on completion of this operation. If, however, hot forming is carried out entirely at a temperature within the normalizing range, subsequent heat treatment will not be required for carbon and carbon- manganese steels. In both instances alloy steels may, in addition, be required to be tempered.

2.7.4.5 All plates which have been cold formed to an internal radius less than 10 times the plate thickness are to be given an appropriate heat treatment.

2.7.4.6 Seams in plates may be welded prior to forming provided that, on completion of forming and subsequent heat treatment, they meet the specified mechanical test requirements and that they are examined radiographically throughout their length after forming. After forming, the surfaces of such seams in alloy steel parts, also carbon steel parts over 25 [mm] in thickness are to be ground smooth and inspected for cracks by magnetic particle crack detection, dye penetration or other means at the discretion of the Surveyors.

2.7.5 Fitting of tubes to drums and headers

2.7.5.1 The tube holes in drums or headers are to be formed in such a way that tubes can be effectively tightened in them. Where the tube ends are not normal to the tube plates, there is to be a neck or belt of parallel seating of at least 13 [mm] in depth, measured in a plane through the axis of the tube at the holes. Where the tubes are practically normal to their plates, this parallel seating is to be not less than 10 [mm] in depth.

2.7.5.2 Tubes are to be carefully fitted in the tube holes and secured by means of welding, expanding and bevelling or by other approved methods. The tubes are to project through the neck or belt of parallel seating by at least 6 [mm] and, where they are secured from drawing out by means of bellmouthing only, the included angle of belling is to be not less than 30 degrees.

2.7.6 Attachments and fittings

2.7.6.1 All lugs, brackets, branches, manhole frames and reinforcements around openings and other members are to conform to the shape of the surface to which they are attached.

2.7.6.2 Doubling plates with well rounded corners are to be fitted in way of attachments such as lifting lugs, supporting brackets and feet, to minimise load concentrations on pressure shells and ends. Compensating plates, pads, brackets, and supporting feet are to bedded closely to the surface before being welded, and are to be provided with a 'tell-tale' hole not greater than 9.5 [mm] in diameter, open to the atmosphere to provide for the release of entrapped air during heat treatment of the vessel, or as a means of indicating any leakage during hydraulic testing and in service

2.7.6.3 The attachment by welding of such fittings to the main pressure shell after post-weld heat treatment is not permitted, except where the material involved is mild steel, when welding will be permitted only if it is necessitated by the method of construction employed. Prior approval of the Surveyor must be obtained before any welding is carried out. In no circumstances is any welding to be carried out after heat treatment on vessels made of carbon or carbon-manganese steels with tensile strength exceeding 500[N/mm^2], or of alloy steel.

2.7.6.4 Where the fittings referred to in 2.7.6.3, together with flats and other attachments for supporting internal and external components, are welded to the main pressure shell, the welding is to be of comparable standard to that required for the vessel, and the material used is to be of compatible composition.

2.7.6.5 The finish of all welds attaching pressure parts and non-pressure parts to the main pressure shell is to be such as to allow satisfactory examination of the welds. In the case of Class 1 pressure vessels, these welds are to be ground smooth, if necessary, to provide a suitable finish for crack detection tests, which are to be carried out to the Surveyor's satisfaction on completion of the hydraulic test.

2.7.7 Tolerances for cylindrical shells

2.7.7.1 Measurements are to be made to the surface of the parent plate, not to a weld, fitting or other raised part.

2.7.7.2 In assessing the out-of-roundness of pressure vessels, the difference between the maximum and minimum internal diameter measured at one cross-section is not to exceed the amount given in Table 2.7.7.1.

2.7.7.3 The profile, measured on the inside or outside of the shell by means of a gauge of designed form of the shell, and having a length equal to one-quarter of the internal diameter of the vessel, is not to depart from the designed form by more than the amount given in Table 2.7.7.1 This amount corresponds to, x, in Fig.2.7.7.1.

Table 2.7.7.1 : Permitted out of roundness

Nominal internal diameter of vessel [mm]	Difference between maximum and minimum diameters	Maximum departure from designed form
≤ 300	1.0 per cent of internal diameter	1.2 [mm]
> 300 ≤ 460		1.6 [mm]
> 460 ≤ 600		2.4 [mm]
> 600 ≤ 900		3.2 [mm]
> 900 ≤ 1220		4.0 [mm]
> 1220 ≤ 1520		4.8 [mm]
> 1520 ≤ 1900		5.6 [mm]
> 1900 ≤ 2300	19 [mm]	6.4 [mm]
> 2300 ≤ 2670		7.2 [mm]
> 2670 ≤ 3950		8.0 [mm]
> 3950 ≤ 4650	19 [mm]	0.2 per cent of internal diameter
> 4650	0.4 per cent of internal diameter	0.2 per cent of internal diameter

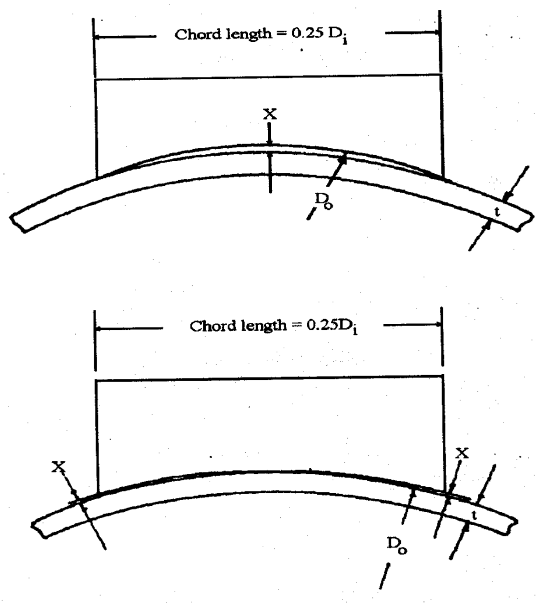


Fig. 2.7.7.1 : Tolerances for cyliderical shells

Table 2.7.7.2 : Circumferential tolerance	
Outside diameter (nominal inside diameter plus twice actual plate thickness) [mm]	**Circumferential tolerance**
300 to 600 inclusive	± 5 [mm]
Greater than 600	± 0.25 per cent

2.7.7.4 Shell sections are to be measured for out-of-roundness, either when laid on their sides or when set up on end. When the shell sections are checked while lying on their sides, each measurement for diameter is to be repeated after turning the shell through 90 degrees about its longitudinal axis. The two measurements for each diameter are to be averaged, and the amount of out-of-roundness calculated from the average values so determined.

2.7.7.5 There are to be no flats or peaks at welded seams, and any local departure from circularity is to be gradual.

2.7.7.6 The external circumference of the completed shell is not to depart from the calculated circumference (based upon nominal inside diameter and actual plate thickness) by more than the amount given in Table 2.7.7.2.

2.8 Non-destructive examination of fusion welded pressure vessels

2.8.1 Radiographic examination

2.8.1.1 The extent of the radiographic examination of welded seams of Class 1 and Class 2 pressure vessels is to be as follows :

a) Class 1 pressure vessels - All butt welded seams in drums, shells, headers and pipes together with the test plate or plates are to be subjected to 100 per cent radiographic examination. For circumferential butt welds in extruded connections, pipes, tubes, headers and other tubular parts of 170 [mm] outside diameter or less, 10 per cent of the total number of welds are to be radiographed;

b) Class 2 pressure vessels - Spot radiographs are to be taken at selected regions of each main seam. The test plate or plates are to be fully radiographed and at least 10 per cent of the length of each main seam is to be so examined.

2.8.1.2 Butt welds in furnaces, combustion chambers and other pressure parts for fired pressure vessels under external pressure, are to be subjected to spot radiographic examination.

2.8.1.3 Where the surface finish of any weld which has to be radiographed is such that it will prevent accurate radiographic examination, the surface is to be machined or ground to provide a smooth contour to the Surveyor's satisfaction.

2.8.1.4 Lead type is to be fixed to the plate adjacent to the weld so that each radiograph is marked in such a way that the corresponding portion of the welded seam can be readily and accurately identified.

2.8.1.5 The length of weld covered by each radiograph is to be such that the metal thickness along the incidental beam at the extremity of the exposure is not to exceed the actual thickness by more than 10 per cent.

2.8.1.6 Image quality indicators (penetrameters) of an approved type are to be placed at either end of each radiograph and on the surface of the plate facing the source of radiation.

2.8.1.7 Image quality indicators of the step-hole type are to be placed alongside the welded seam, parallel to its length, and are to have a hole in each step of a diameter corresponding to thickness at that step, or are to have some similar device whereby the step thickness can be identified when the radiographic film is examined.

2.8.1.8 The radiographic technique employed is to be such that the smallest diameter hole visible in the radiograph is not to exceed 3 per cent of the weld thickness for welds not exceeding 50 [mm] thick, or 2.5 per cent for welds exceeding 50 [mm] thick. The steps are to bear these proportions to the weld thickness radiographed, and the radiographic technique is to be capable of revealing changes of metal thickness of these percentages.

2.8.1.9 Image quality indicators of the wire type are to be placed across the weld, and the smallest diameter wire which can be seen in the radiograph is to have a diameter not greater than 1.5 per cent of the weld thickness if the weld thickness is between 10 [mm] and 50 [mm], and not greater than 1.25 per cent of the weld metal thickness if the thickness is between 50 and 200 [mm].

2.8.1.10 The use of gamma-rays may be permitted in certain circumstances, and details should be submitted for consideration and approval.

2.8.1.11 Radiographs are to be examined by the Surveyors on the original films using a viewing device of suitable illuminating power.

2.8.2 Ultrasonic examination

2.8.2.1 In Class 1 pressure vessels where plate thickness exceeds 50 [mm], ultrasonic examination may be accepted as an alternative to radiographic examination. Such examination is to be effected by an approved operator using an approved technique and an approved recording system. Supplementary examination by radiography may be required at selected locations.

2.8.3 Magnetic particle testing

2.8.3.1 In Class 1 and Class 2 pressure vessels, the welds on standpipes, compensating plates, stubs and branches, etc. of ferritic steel which have not been radiographed are to be magnetic particle tested at the rate of 10 per cent of such welds. This may be increased or decreased, if not practicable, at the discretion of the Surveyors. For non-magnetic materials, dye penetrant examination will be accepted.

2.9 Repairs to welded seams on fusion welded pressure vessels

2.9.1 Class 1

2.9.1.1 In the case of Class 1 pressure vessels where non-destructive tests show unacceptable defects in the welded seams, the defects are to be repaired and are to be shown by further non-destructive tests to have been eliminated to the Surveyor's satisfaction.

2.9.2 Class 2

2.9.2.1 In the case of Class 2 pressure vessels, when a spot radiograph reveals unacceptable defects in the welded seam, at least two further radiographs are to be made in the length of weld represented by the first radiograph, in locations selected by the Surveyor. If these reveal no further unacceptable defects, the defects revealed by the first radiograph are to be repaired and re-radiographed. If the check radiographs reveal unacceptable defects, then either :

a) the whole length of weld represented is to be cut out and rewelded, then subjected to spot radiography as if it were a new weld, and the original test plates associated with the weld are to be similarly treated; or

b) the whole length of the weld represented is to be radiographed. Unacceptable defects are to be repaired and are to be shown by radiography to have been eliminated.

2.10 Post-weld heat treatment of pressure vessels

2.10.1 General

2.10.1.1 Dependent upon the grade of steel and plate thickness, Class 1 and Class 2 pressure vessels, where indicated in Table 2.10.1, are to be efficiently heat treated on completion of the welding of the seams and of all attachments to the shell and ends, and before the hydraulic test is carried out.

Table 2.10.1 : Post-weld heat treatment

Type of steel	Plate thicknesses [mm], above which post-weld heat treatment is required	
	Steam raising plant	Other pressure vessels
Carbon and carbon manganese steels with minimum specified tensile strengths between 360 to 510 [N/mm^2] without low temperature impact values	20	30
Carbon and carbon manganese steels with minimum specified tensile strengths between 360 to 510 [N/mm^2] with low temperature impact values of 27 J at -20°C or 10°C below design temperature whichever is lower	Not applicable	40
Alloy steels	All thicknesses to be heat treated	

2.10.2 Basic requirements

2.10.2.1 Heat treatment is to be carried out in a properly constructed furnace which is efficiently maintained and has adequate means of temperature control, and is fitted with pyrometers which will measure and record the temperature of the furnace charge.

2.10.2.2 The heat treatment is to consist of heating the vessel slowly and uniformly to a suitable stress relieving temperature, soaking for a suitable period, followed by cooling slowly and uniformly in the furnace to a temperature not exceeding 400°C and subsequently cooling in a still atmosphere.

2.10.2.3 The temperature and soaking periods are to be so selected as to relieve residual stresses without undue deterioration of the properties of the material.

2.10.2.4 Recommended soaking temperatures and periods are given in Table 2.10.2.

Table 2.10.2 : Recommended soaking temperatures and periods

Type of steel	Soaking temp. in °C	Time at recommended temperatures, per 25 [mm] of thickness
Carbon and carbon manganese	580 - 620	1 hour, minimum period 1 hour
1 Cr 1/2 Mo	620 - 660	1 hour, minimum period 2 hour
2 1/4 Cr 1 Mo	660 - 690	2 hours, minimum period 2 hours

2.10.2.5 Where materials other than those detailed in Table 2.10.2 are used for pressure vessel construction, full details of the proposed heat treatment are to be submitted for consideration.

2.10.2.6 Where pressure vessels are of such dimensions that the whole length cannot be accommodated in the furnace at one time, the pressure vessels may be heated in sections, provided that sufficient overlap is allowed to ensure the heat treatment of the entire length of the longitudinal seam.

2.10.2.7 Where it is proposed to adopt special methods of heat treatment, full particulars are to be submitted for consideration. In such cases it may be necessary to carry out tests to show the effect of the proposed heat treatment.

2.10.3 Test assemblies

2.10.3.1 Test assemblies are to be heat treated in the same furnace and at the same time as the pressure vessels which they represent.

2.10.3.2 Alternatively, it may be permissible to heat treat the test plates separately from the pressure vessels, provided that the Surveyor is satisfied with the means adopted to ensure that the following factors will be the same for the pressure vessels as for their respective test assemblies:

a) Rate of heating;

b) Maximum temperature;

c) Time held at maximum temperature; and

d) Condition of cooling.

Section 3

Welded Pressure Pipes

3.1 General

3.1.1 Manual or semi-automatic electric arc welding is to be used for butt and socket welded joints in pipes, for branch pieces and for the attachment of flanges. Oxy-acetylene welding may also be used, but, in general, is suitable only for butt joints in pipes not exceeding 100 [mm] diameter or 9.5 [mm] thickness.

3.1.2 Where pressure pipelines are assembled and butt welded in place, the piping is to be arranged well clear of adjacent structures to allow sufficient access for preheating welding, heat-treatment and examination of the joints.

Joint preparation, tolerances and edge preparation, are to be appropriate to the welding process and in accordance with recognized standards and/or approved drawings. The preparation of edges is to be carried out by mechanical means and where flame cutting is used, oxide scales, notches are to be removed by grinding or chipping back to sound metal.

3.1.3 Butt welded joints shall be full penetration type with details according to the following:

a) For class I piping:

- Double vee groove joint or
- with a backing strip or equivalent

b) For class II and III piping:

- a single vee groove joint or equivalent

The tolerances on the alignment of pipes to be welded are to be in accordance with Table 3.1.1. Higher tolerances for class III pipes may be specially considered.

3.1.4 Slip-on sleeve and socket welded joints

Slip-on sleeve and socket welded joints are to have sleeves, sockets and weldments of adequate dimensions conforming to IRS Rules or recognized standard.

Slip-on sleeve and socket welded joints may be used in Class III piping systems, of any outside diameter.

In particular cases, slip-on sleeve and socket welded joints may be allowed by IRS for piping systems of Class I and Class II having outside diameter less than or equal to 88.9 [mm] except for piping systems conveying toxic media or services where fatigue, severe erosion or crevice corrosion is expected to occur.

3.1.5 Acceptable methods of flange attachment are illustrated in Fig.2.3.1 in Ch.2.

3.1.6 Welding consumables meeting the rule requirements and, where used, fusible root inserts, are to be suitable for the materials being joined.

3.1.7 All welds in high pressure and high temperature pipelines are to have a smooth surface finish and even contour, if necessary they are to be made smooth by grinding.

3.1.8 Preheating under temperature control is to be employed in accordance with Table 3.1.2, when necessitated by the dimensions and composition of the materials to be welded and is to be effected by a method which ensures uniformity of temperature at the joint. The method of heating and the means adopted for temperature control are to be to the satisfaction of the Surveyors.

Table 3.1.1 : Tolerances on alignment of pipes

Diameter and thickness of pipes	Tolerances [mm]
All diameter and thickness with permanently fitted backing ring	0.5
Pipes welded without backing ring - Inside diameter < 150 mm and thickness upto 6.0 mm included - Inside diameter < 300 mm and thickness upto 9.5 mm included - Inside diameter 300 mm and above and thickness > 9.5 mm	 1.0 1.5 2.0

Table 3.1.2 : Preheating temperatures

Type of steel		**Thickness of thicker part [mm]**	**Minimum preheating temperature (°C)**
C and C-Mn steels	$C + \frac{Mn}{6} \leq 0.40$	≥ 20 (2)	50
	$C + \frac{Mn}{6} \leq 0.40$	≥ 20 (2)	100
0.3 Mo		> 13 (2)	100
1 Cr – 0.5 Mo		< 13 ≥ 13	100 150
2.25 Cr – 1 Mo and 0.5 Cr – 0.5 Mo – 0.25 V (1)		< 13 ≥ 13	150 200

Notes :

1. For these materials, preheating may be omitted for thicknesses upto 6 [mm] if the results of hardness tests carried out on welding procedure qualification are considered acceptable by IRS.

2. For welding in ambient temperature below 0°C, the minimum preheating temperature is required regardless of the thickness unless specifically approved by IRS.

The values given in the Table 3.1.2 are based on the use of low hydrogen processes. Higher preheating temperatures may be employed when low hydrogen processes are not used.

3.1.9 The welding procedure proposed for the attachment of flanges, valve chests and other fittings to pipes, pipes-to-pipes and the fabrication of branch pieces, whether in carbon or alloy steel, is to be approved by the Surveyors in the first instance before work is commenced. For this purpose representative specimens of such parts will be required for examination and testing.

Tack welds forming part of the finished weld are to be made using approved, welding procedure.

3.1.10 The assembly for the weld procedure test and the welding technique should simulate the conditions under which the work is to be done on the installation. Test welds are to be examined for defects by the appropriate method specified in 3.2.2 to 3.2.4. The test welds are then to be sectioned at positions selected by the Surveyor, one surface of each section being prepared, etched and examined for defects in the weld and heat effected zones.

3.1.11 In the case of pipes of branch pieces of alloy steel, mechanical tests and tests to destruction may also be required to demonstrate that the joints are of adequate strength.

3.1.12 Check tests of the quality of the welding are to be carried out periodically at the discretion of the Surveyors.

3.2 Non-destructive examination of welded pipes

3.2.1 In addition to visual examination of pipes welds by the Surveyors, non-destructive examination of butt and fillet welds is to be carried out in accordance with 3.2.2 to 3.2.5 to the satisfaction of the Surveyors.

Radiographic and ultrasonic examination is to be carried out with an appropriate technique by trained operators using an approved procedure depending on the criticality of the joint.

3.2.2 Butt welds are to be subjected to radiographic examination in accordance with Table 3.2.1. For radiographic examinations and required standards of sensitivity, See 2.8.

3.2.3 The use of ultrasonic examination in lieu of radiographic examination as required by 3.2.2 will be specially considered.

Table 3.2.1 : Radiographic examination of butt welds

Class of pipe	Outside diameter of pipe	Extent of examination
I	≤ 76.1 [mm]	Selected welds at Surveyor's discretion
	> 76.1 [mm]	100 percent of welds
II	> 101.6 [mm]	Selected welds at Surveyor's discretion Atleast 10% 1)

Note 1) Surveyor may apply more stringent requirement depending upon kind of materials, welding procedure and controls exercised during fabrication.

Table 3.2.2 : Magnetic particle or liquid penetrant flaw detection testing of fillet welds

Class of pipe	Outside diameter of pipe	Extent of examination
I	≤ 76.1 [mm]	Selected welds at Surveyor's discretion
	> 76.1 [mm]	100 percent of welds
II	> 101.6 [mm]	Selected welds at Surveyor's discretion

3.2.4 Fillet welds are to be subjected to magnetic particle or liquid penetrant flaw detection testing in accordance with Table 3.2.2.

The equipment is to be suitable for flaw detection and may require calibration against standard samples. The acceptance criteria for welds is to be generally in accordance with the national or international standard.

3.2.5 Defects in welds are to be rectified and re-examined by the appropriate test method, all to the satisfaction of the Surveyors.

3.2.6 Ultrasonic examination may be required in special cases in addition to above non-destructive testing.

3.3 Post-weld heat treatment

3.3.1 Carbon and carbon-manganese steel pipes and fabricated branch pieces having a thickness exceeding 30 [mm] are to be heat treated on completion of fusion welding. All thicknesses of alloy steel pipes and branch pieces are to be heat treated on completion of fusion welding.

3.3.2 Recommended soaking temperatures and periods for post-weld heat treatment are given in Table 3.3.1.

3.3.3 Any proposal to use oxy-acetylene welding for the fabrication of pipes and branch pieces will be the subject of special consideration. Due consideration should be given to the need for normalizing and tempering after such welding.

3.4 Heat treatment after forming of pipes

3.4.1 Heat treatment should preferably be carried out in a suitable furnace provided with temperature recording equipment without impairing the specified properties of the materials. Tests may be carried out if necessary. Localized heat treatment of welded joints extended sufficiently along the pipe length on either side of the joint, carried out with approved procedure, can be also accepted.

Table 3.3.1 : Post-weld heat treatment	
Type of steel	**Heat treatment of temperature °C**
Carbon and carbon-manganese	Normalizing 880 to 940
0.3 Mo	Normalizing 900 to 940
1 Cr 1/2 Mo	Normalizing 900 to 960 tempering 640 to 720
2 1/4 Cr 1 Mo	Normalizing 900 to 960 Tempering 650 to 780
0.5 Cr – 0.5 Mo – 0.25V	Normalizing 930 to 980 Tempering 670 to 720
Other alloys steels	Subject to special consideration

Table 3.3.2 : Stress relieving temperatures		
Type of steel	**Thickness of thicker part [mm]**	**Stress relief heat treatment temperature (°C)**
C and C-Mn	≥ 15 (1) (3)	550 to 620
0.3 Mo	≥ 15 (1)	580 to 640
1 Cr – 0.5 Mo	> 8	620 to 680
2.25 Cr – 1 Mo and 0.5 Cr – 0.5 Mo – 0.25 V	Any (2)	650 to 720

Notes:

1. When steels with specified Charpy V notch impact properties at low temperature are used, the thickness above which postweld heat treatment shall be applied may be increased by special agreement with IRS.

2. Heat treatment may be omitted for pipes having thickness ≤ 8 [mm], diameter ≤ 100 [mm] and minimum service temperature 450°C.

3. For C and C-Mn steels, stress relieving heat treatment may be omitted upto 30 [mm] thickness by special agreement with IRS.

3.4.2 Hot forming should generally be carried out within the normalizing temperature range of 850 – 1000°C for all grades. When carried out within this temperature range no subsequent heat treatment is required for carbon, carbon-manganese and carbon-molybdenum steels. For Chrome-molybdenum and Carbon-molybdenum-vanadium steels, a subsequent stress relieving heat treatment is to be carried out in accordance with Table 3.3.2. When the hot forming is carried out outside the normalizing temperature range, a subsequent heat treatment in accordance with Table 3.3.1 is required.

3.4.3 After cold forming, when bent to a radius measured at the centerline of the pipe of less than four times the outside diameter, heat treatment in accordance with Table 3.3.1 is required.

In any case, a stress relieving heat treatment is to be carried out in accordance with Table 3.3.2 for all grades other than carbon and carbon-manganese steels having UTS 320, 360 and 410 [N/mm^2].

3.4.4 Stress relieving is to be carried out after welding for other than oxy-acetylene welding process in accordance with Table 3.3.2.

The stress relieving heat treatment is to consist in heating the piping slowly and uniformly to a temperature within the range indicated in the table, soaking at this temperature for a suitable period, in general one hour per 25 [mm] of thickness with minimum half an hour, cooling slowly and uniformly in the furnace to a temperature not exceeding 400°C and subsequently cooling in a still atmosphere.

3.4.5 For oxy-acetylene welding, heat treatment is to be carried out depending upon the type of steel in accordance with Table 3.3.1.

End of Chapter

Chapter 11

Spare Gear

Contents

Section

Section 1

General Requirements

1.1 General

1.1.1 Adequate spare parts for propelling and essential auxiliary machinery together with the necessary tools for maintenance and repair are to be readily available for use.

1.1.2 The spare parts to be supplied and their location is the responsibility of the Owners but must take into account the design and arrangements of the machinery and the intended service and operation of the ship. Account should also be taken of the recommendations of the manufacturers and any applicable statutory requirements of the country of registration of the ship.

Section 2

Spare Parts Recommended for Main and Auxiliary Machinery Installations

2.1 List of minimum required spare parts

2.1.1 The spare parts recommended for main and auxiliary machinery installations are shown in the following Tables:-

Table 2.1.1 :	Spare parts for main internal combustion engines;
Table 2.1.2 :	Spare parts for main steam turbines;
Table 2.1.3 :	Spare parts for auxiliary steam turbines;
Table 2.1.4 :	Spare parts for auxiliary internal combustion engines driving electric generators for essential services;
Table 2.1.5 :	Spare parts for main and auxiliary boilers;
Table 2.1.6 :	Spare parts for auxiliary machinery.

2.1.2 In ships with multi-engine installations, spare parts need only be carried for one main engine.

2.1.3 Where additional units of adequate capacity are fitted, for auxiliary machinery of each type required for essential services, no spare parts are required.

Table 2.1.1 : Spare parts for main internal combustion engines

Sr. No.	Item	Spare parts	Number required	
			Ships for unrestricted service	Ships for restricted service
1	Main bearings	Main bearings or shells for one bearing of each size and type fitted, complete with shims, bolts and nuts	1	-
2	Main thrust block	Pads for one face of Michell type thrust block, or	1 set	1 set
		Complete white metal thrust shoe of solid ring type, or	1	1
		Inner and outer race with rollers, where roller thrust bearings are fitted	1	1
3	Connecting rod bearings	Bottom end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder	1 set	-
		Top end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder	1 set	-
4	Cylinder liner	Cylinder liner, complete with joint rings and gaskets	1	-
5	Cylinder cover	Cylinder cover, complete with valves, joint rings and gaskets. For engines without covers the respective valves for one cylinder unit	1	-
		Cylinder cover bolts and nuts for one cylinder	Half set	-
6	Cylinder valves	Exhaust valves, complete with casings, seats, springs and other fittings for one cylinder	2 sets	1 set
		Air inlet valves, complete with casings, seats, springs and other fittings for one cylinder	1 set	1 set
		Starting air valve, complete with casing, seat, springs and other fittings	1	1
		Cylinder overpressure sentinel valve, complete	1	1
		Fuel valves of each size and type fitted complete with all fittings, for one engine	1 set see foot note 1	1/4 set
7	Pistons	Crosshead type: Piston of each type fitted, complete with piston rod, stuffing box, skirt, rings, studs and nuts	1	-
		Trunk piston type: Piston of each type fitted, complete with skirt, rings, studs, nuts, gudgeon pin and connecting rod	1	-
8	Piston rings	Piston rings, for one cylinder	1 set	-
9	Piston cooling	Telescopic cooling pipes and fittings or their equivalent, for one cylinder unit	1 set	-
10	Cylinder lubricators	Lubricator complete, of the largest size, with its chain drive or gear wheels	1	-
11	Fuel injection pumps	Fuel pump complete, or when replacement at sea is practicable, a complete set of working parts for one pump (plunger, sleeve, valves springs etc).	1	-
12	Fuel injection piping	High pressure fuel pipe of each size and shape fitted, complete with couplings	1	-
13	Scavenge blowers (including turbochargers)	Rotors, rotor shafts, bearings, nozzle rings and gear wheels or equivalent working parts of other types	1 set see foot note 2	-
14	Scavenging system	Suction and delivery valves for one pump of each type fitted	1 set	-

Table 2.1.1 : Spare parts for main internal combustion engines (Contd.)

Sr. No.	Item	Spare parts	Number required	
			Ships for unrestricted service	**Ships for restricted service**
15	Reduction and/or reverse gear	Complete bearing bush, of each size fitted in the gear case assembly	1 set	-
		Roller or ball race, of each size fitted in the gear case assembly	1 set	-
16	Main engine driven air compressors	Piston rings of each size fitted	1 set	-
		Suction and delivery valves complete of each size fitted	Half set	-
17	Special gaskets and packing of each size and type fitted for cylinder cover and cylinder liner for one cylinder		1 set	-

Footnotes :

1 (a) Engines with one or two fuel valves per cylinder: one set of valves, complete.

(b) Engines with 3 or more fuel valves per cylinder : two fuel valves complete per cylinder and a sufficient number of valve parts, including the body, to form with those fitted in the complete valves, a full engine set.

2 The spare parts may be omitted where it has been demonstrated, at the builder's test bench for one engine of the type concerned that the engine can be maneuvered satisfactorily with one blower out of action.

The requisite blanking and blocking arrangements for running with the blower out of action are to be available on board.

Notes

1 The availability of other spare parts, such as gears and chains for camshaft drive, should be specially considered and decided upon by the Owners.

2 When the spare parts are utilized, new spare parts are to be supplied as soon as possible.

Table 2.1.2 : Spare parts for steam turbines for main propulsion

Sr. No.	Item	Spare parts	Number required	
			Ships for unrestricted service	**Ships for restricted service**
1	Main bearing	Bearing bushes, of each size and type fitted for the rotor, pinion and gear wheel shafts, for one engine	1	-
2	Turbine thrust	Pads of each size for one face of Michell type thrust or rings for turbine adjusting block, or each size fitted for one engine. Assorted liners for 1 block where fitted	1 set	1 set
3	Main thrust block	Pads for one face of Michell type thrust block, or	1 set	1 set
		Complete white metal thrust shoe of solid ring type, or	1	1
		Inner and outer race with rollers where roller thrust bearings are fitted	1	1
4	Turbine shaft	Carbon sealing rings, where fitted, with springs for each size of sealing rings and type of gland	1 set	1 set
5	Oil filters	Strainer baskets or inserts for filters of special design of each type and size	1 set	1 set

Notes

1 The availability of other spare parts should be specially considered and decided upon by the Owners.

2 When the spare parts are utilized, new spare parts are to be supplied as soon as possible.

Table 2.1.3 : Spare parts for auxiliary steam turbines				
Sr. No.	**Item**	**Spare parts**	**Number required**	
			Ships for unrestricted service	**Ships for restricted service**
1	Main bearings	Bearing bushes or roller bearings of each size and type fitted for the shafts of the turbine rotor and of the reduction gearing, if any, for one engine	1	1
2	Turbine thrust	Pads of each size for one face of Michell type thrust or rings for turbine adjusting block, or each size fitted for one engine. Assorted liners for 1 block where fitted	1 set	1 set
3	Turbine shaft	Carbon sealing rings, where fitted, with springs, for each size of sealing rings and type of gland, for one engine	1 set	1 set
4	Oil filters	Strainer baskets or inserts, for filters of special design, of each type and size	1 set	1 set
Notes 1 The availability of other spare parts should be specially considered and decided upon by the Owners. 2 When the spare parts are utilized, new spare parts are to be supplied as soon as possible.				

Table 2.1.4 : Spare parts for auxiliary internal combustion engines driving electric generators for essential services				
Sr. No.	**Item**	**Spare parts**	**Number required**	
			Ships for unrestricted service	**Ships for restricted service**
1	Main bearings	Main bearings or shells for one bearing of each size and type fitted, complete with shims, bolts and nuts	1	-
2	Cylinder valves	Exhaust valves, complete with casings, seats, springs and other fittings for one cylinder	2 sets	-
		Air inlet valves, complete with casings, seats, springs and other fittings for one cylinder	1 set	-
		Starting air valve, complete with casing, seat, springs and other fittings	1	-
		Cylinder overpressure sentinel valve, complete	1	-
		Fuel valves of each size and type fitted complete with all fittings, for one engine	Half set	-
3	Connecting rod bearings	Bottom end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder	1 set	-
		Top end bearings or shells of each size and type fitted, complete with shims, bolts and nuts, for one cylinder	1 set	-
		Trunk piston type : gudgeon pin with bush for one cylinder	1 set	-
4	Piston rings	Piston rings, for one cylinder	1 set	-
5	Piston cooling	Telescopic cooling pipes and fittings or their equivalent, for one cylinder unit	1 set	-
6	Fuel injection pumps	Fuel pump complete, or when replacement at sea is practicable, a complete set of working parts for one pump (plunger, sleeve, valves springs etc).	1	-
7	Fuel injection piping	High pressure fuel pipe of each size and shape fitted, complete with couplings	1	-
8	Gaskets and packings	Special gaskets and packings of each size and type fitted, for cylinder covers and cylinder	1 set	-

Table 2.1.5 : Spare parts for boilers (main and auxiliary)

Sr. No.	Item	Spare parts	Number required	
			Ships for unrestricted service	Ships for restricted service
1	Tube stoppers or plugs	Tube stoppers or plugs, of each size used, for boiler superheater and economiser tubes	20	10
2	Fire bars	Fire bars for one boiler, where coal fired	1 set	Half set
3	Oil fuel burners	Oil fuel burners complete, for one boiler	1 set	1 set
4	Gauge glasses	Gauge glasses of round type	2 sets per boiler	2 sets per boiler
		Gauge glasses of flat type	1 set for every two boilers	1 set for every two boilers

Table 2.1.6 : Spare parts for auxiliary machinery

Sr. No.	Item	Spare parts	Number required	
			Ships for unrestricted service	Ships for restricted service
Pumps				
1	**Reciprocating pumps**			
1.1	Valves	Valve with seats and springs, each size fitted	1 set	1 set
1.2	Piston rings	Piston rings, each type and size for one piston	1 set	1 set
2	**Centrifugal pumps**			
2.1	Bearings	Bearing of each type and size	1	1
2.2	Rotor	Rotor sealing of each type and size	1	1
3	**Gear type pumps**			
3.1	Bearing	Bearing of each type and size	1	1
3.2	Rotor	Rotor sealing of each type and size	1	1
Air compressor				
1	Piston rings	Rings of each size fitted for one piston	1 set	1 set
2	Valves	Suction and delivery valves, complete, of each size fitted	Half set	Half set

Notes

1 The availability of other spare parts should be specially considered and decided upon by the Owners.

2 When the spare parts are utilized, new spare parts are to be supplied as soon as possible.

3 When a sufficiently rated standby pump is available, spare part for the pump may be dispensed with.

End of Chapter

Rules and Regulations for the Construction and Classification of Steel Ships

Part 5

Special Ship Types

Volume I

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IRCLASS
Indian Register of Shipping

Indian Register of Shipping

Part 5 : Special Ship Types

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Chapter 1

Dry Bulk Cargo Carriers

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Section 1

General

1.1 Application, definitions, class notations and documentation

1.1.1 Application

1.1.1.1 The requirements of this chapter apply in general to all bulk carriers as defined in 1.1.2.1 except for hull structures of those vessels mentioned in 1.1.1.2 below. The requirements are supplementary to those given for the assignment of main character of class.

1.1.1.2 The IACS common structural rules (CSR), for bulk carriers are to be applied to hull structures of seagoing self propelled bulk carriers of unrestricted service and having a length L of 90 [m] and above, which are constructed generally with single deck, double bottom, hopper side tanks and topside tanks and with single or double skin construction in cargo area, excluding ore and combination carriers. The CSR is also applicable to hybrid bulk carriers, when at least one cargo hold is constructed with hopper tank and top side tank.

Accordingly the following requirements of this chapter will not apply to CSR bulk carriers:

Section 1 – Subsections 1.2, 1.3, 1.4
Section 2 – Subsections 2.1 to 2.11
Section 3 – All subsections (3.1 to 3.6)
Section 4 – All subsections (4.1 to 4.3)
Section 5 – All subsections (5.1 to 5.6).

1.1.1.3 The requirements of SOLAS Chapter XII - Additional safety measures for bulk carriers, apply to bulk carriers of "single side skin construction" and of “double side skin construction” as defined in 1.1.2.3.

1.1.2 Definitions

1.1.2.1 Bulk carrier means a ship which is intended primarily to carry dry cargo in bulk, including such types as ore carriers and combination carriers.

1.1.2.2 “Bulk carrier of single side skin construction” means a bulk carrier in which:

a) any part of a cargo hold is bounded by the side shell; or

b) where one or more cargo holds are bounded by a double side skin, the width of which is less than 760 [mm] in bulk carriers constructed before 1 January, 2000 and less than 1000 [mm] in bulk carriers constructed on or after 1 January, 2000 but before 1 July, 2006, the distance being measured perpendicular to the side shell. Such ships include combination carriers in which any part of a cargo hold is bounded by the side shell.

1.1.2.3 “Bulk carriers of double side skin construction” means a bulk carrier in which all cargo holds are bounded by a double-side skin, other than as defined in b) above.

1.1.2.4 “Double side skin” means a configuration where each ship side is constructed by the side shell and longitudinal bulkhead connecting the double bottom and the deck. Hopper side tanks and top-side tanks may, where fitted, be integral parts of the double side skin construction. Double side skin construction is to comply with the requirements of 1.8.

1.1.3 Class notations

1.1.3.1 When the IACS Common Structural Rules (CSR) are applied as mentioned in 1.1.1.2 above, the vessel will be eligible to be assigned class notation '**CSR**' and additional notations as per the Common Structural Rules, as applicable.

1.1.3.2 In general, bulk carriers other than those to which CSR is applied built in compliance with the above requirements, as applicable, will be eligible to be assigned one of the following class notations:

BULK CARRIER, ESP
BULK CARRIER, "Strengthened for heavy Cargoes", ESP
BULK CARRIER, "Strengthened for heavy Cargoes, hold(s) ... (to be specified) **... may be empty", ESP.**

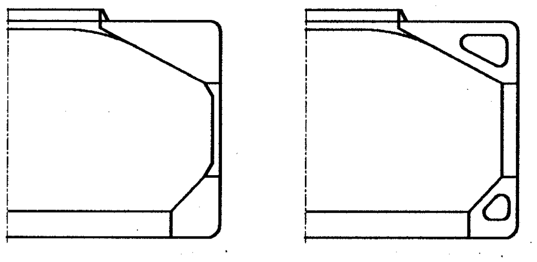


Fig.1.1.3.6(a): Typical midship section of bulk carriers

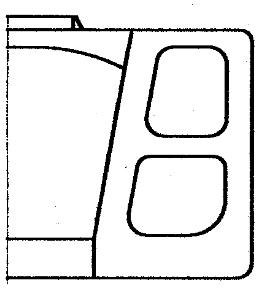


Fig.1.1.3.6(b): Typical midship section of ore carrier

1.1.3.3 The notation "BULK CARRIER" implies that the vessel is largely designed for homogeneous loading in all holds and any hold may be filled up to the top of hatch coaming with bulk cargo of density at least upto 0.8 [t/m^3] when draught in way of the hold is 0.6T or more. It is also implied that no hold will be empty when the draught in way of the hold is greater than 0.6T.

1.1.3.4 The notation "BULK CARRIER", "Strengthened for heavy cargoes" implies that the vessel is designed for heavier bulk cargo loadings due to uneven distributions among the cargo holds and any hold may be filled up to the top of hatch coaming with bulk cargo of density at least upto 1.0 [t/m^3] when draught in way of the hold is 0.8T or more. It is also implied that no hold will be empty when the draught in way of the hold is greater than 0.8T.

1.1.3.5 The notation "BULK CARRIER", "Strengthened for heavy cargoes, hold(s) ... (to be specified) ... may be empty" implies that the vessel is also designed for heavy bulk cargo loading in non-homogeneous loading conditions with approved arrangement of empty holds at the fully loaded draught T. Where found appropriate, the 'specification' of empty hold(s) may be suitably worded to include the requested combinations of empty holds. e.g. "(Any hold may be empty)" or "(Holds 2, 4, 6 or 3, 5, 7 may be empty)".

1.1.3.6 Assignment of class notation **ESP** (Enhanced Survey Program) is mandatory for bulk carriers of single or double skin construction, with a double bottom, hopper side tanks and topside tanks fitted below the upper deck and for ore carriers having two longitudinal bulkheads and a double bottom throughout the cargo region and intended primarily to carry ore cargoes in the centre hold only. Typical cross sections of such bulk carriers and ore carriers are given in Fig.1.1.3.6a and Fig.1.1.3.6b respectively. Class notation '**ESP**' may be assigned to other types of bulk carriers, when required by the Administration.

1.1.3.7 Ore carriers built in compliance with the above mentioned requirements, as applicable, will be eligible to be assigned class notation "**ORE CARRIER, ESP**".

1.1.4 Documentation

1.1.4.1 The following additional documents are to be submitted for approval, as applicable:

a) Plan showing the cross sections taken at mid-length of each hold and the hold capacities upto the top of hatch coaming.

b) Maximum allowable and minimum required mass of cargo and double bottom contents of each hold as a function of the draught at mid-hold position.

c) Design values of maximum density of bulk cargo to be carried in each hold when the cargo is filled upto top of the hatch coaming. Corresponding angles of repose to be indicated.

d) Details of all (mandatory and other envisaged) homogeneous and/or non-homogeneous loading conditions giving various combinations of filling levels in holds, combinations of empty and loaded holds including possible part loading/unloading conditions in the homogeneous mode and loading conditions where two adjacent holds are loaded fully with adjacent holds empty (block loading). In ballast conditions where water ballast is intended to be carried in holds, details of filling levels are to be included. Calculations of still water bending moments and shear forces in these conditions are to be submitted along with the limiting values to be included in the loading manual and the loading instrument.

e) Where applicable, calculations of still water bending moments and shear forces in flooded conditions, as detailed in 2.2.2 to 2.2.6.

f) Typical cargo loading/unloading sequences and sequences for change of ballast at sea as indicated in 1.2.1(h) and (i) respectively.

1.2 Loading guidance information - additional requirements

1.2.1 Bulk carriers, ore carriers and combination carriers of length 150 [m] and above, are to comply with the following in addition to the general requirements given in Pt.3, Ch.5.

i) The loading manual is to contain the additional information as per 1.2.2 and also include additional loading conditions given in 1.2.3; and

ii) The computer-based loading instrument is to have additional capabilities as per 1.2.4 and its approval is to subjected to the additional conditions of approval given in 1.2.5.

1.2.2 Loading manual shall contain complete information with respect to:

a) The loading conditions on which the design of the ship has been based, including permissible limits of still water bending moments and shear forces;

b) The results of the calculations of still water bending moments, shear forces and where applicable, limitations due to torsional loads;

c) Where the longitudinal strength in flooded condition is required to be checked according to 2.2.2, envelope results and permissible limits of still water bending moments and shear forces in the hold flooded condition;

d) The cargo hold(s) or combination of cargo holds that might be empty at full draught. If no cargo hold is allowed to be empty at full draught, this is to be clearly stated in the loading manual;

e) Maximum allowable and minimum required mass of cargo and double bottom contents of each hold as a function of the draught at mid-hold position.

f) Maximum allowable and minimum required mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds. This mean draught may be calculated by averaging the draught of the two mid-hold positions.

g) Maximum allowable tank top loading together with specifications of the nature of the cargo for cargoes other than bulk cargoes;

h) Maximum allowable load on deck and hatch covers. If the vessel is not approved to carry load on the deck or hatch covers, this is to be clearly stated in the loading manual;

i) The maximum rate of ballast change together with the advice that a load plan is to be agreed with the terminal on the basis of the achievable rates of change of ballast.

1.2.3 The following additional conditions, subdivided into departure and arrival conditions as appropriate, are to be included in the Loading Manual:

a) Alternate light and heavy cargo loading conditions at maximum draught, where applicable;

b) Homogeneous light and heavy cargo loading conditions at maximum draught;

c) Ballast conditions. For vessels having ballast holds adjacent to topside wing, hopper and double bottom tanks, it shall be strengthwise acceptable that the ballast holds are filled when the topside wing, hopper and double bottom tanks are empty. Partial filling of the peak tanks is not acceptable in the design ballast conditions unless effective means are provided to prevent accidental overfilling;

d) Short voyage conditions where the vessel is to be loaded to maximum draught but with limited amount of bunkers;

e) Multiple port loading/unloading conditions;

f) Deck cargo conditions, where applicable;

g) Typical loading/unloading sequences as detailed in 1.2.4;

h) Typical sequences for change of ballast at sea, where applicable.

1.2.4 Typical loading/unloading sequences are to be prepared, considering the various intermediate stages from commencement to completion of the loading/unloading operation relevant to all envisaged loading conditions including the following:

- alternate light and heavy cargo load condition,
- homogeneous light and heavy cargo load condition,
- short voyage condition where the ship is loaded to maximum draught but with limited bunkers,
- multiple port loading/unloading condition,
- deck cargo condition,
- block loading.

The loading/unloading sequences may be port specific or typical.

The sequence is to be built up step by step from commencement of cargo loading to reaching full deadweight capacity. Each time the loading equipment changes position to a new hold defines a step. Each step is to be documented and submitted. In addition to longitudinal strength, the local strength of each hold is to be considered.

For each loading condition a summary of all steps is to be included. This summary is to highlight the essential information for each step such as:

- How much cargo is filled in each hold during the step.

- How much ballast is discharged from each ballast tank during the step.

- The maximum still water bending moment and shear at the end of the step.

- The ship's trim and draught at the end of the step.

1.2.5 The digital loading instrument shall also be capable of ascertaining, as applicable, the following:

- The mass of cargo and double bottom contents in way of each hold as a function of the draught at mid-hold position;

- The mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds;

- Where the longitudinal strength in flooded condition is required to be checked according to 2.2.2, the still water bending moment and shear forces in the hold flooded conditions are within permissible values.

1.2.6 The approval of loading instrument is to be based on the following additional conditions, as applicable:

a) Acceptance of hull girder bending moment limits for all read-out points.

b) Acceptance of hull girder shear force limits for all read-out points.

c) Acceptance of limits for mass of cargo and double bottom contents of each hold as a function of draught.

Acceptance of limits for mass of cargo and double bottom contents in any two adjacent holds as a function of draught.

1.3 Design loads in cargo holds

1.3.1 Definitions

ρ_f = value of maximum density of bulk cargo to be carried in the hold under consideration when cargo is filled upto the top of hatch coaming in any loading condition.

Note : Unless the ship is designed to carry, in non-homogeneous conditions, only iron ore or cargo of density equal to or more than 1.78 [t/m^3], the maximum mass of cargo allowed to be carried in a cargo hold in any loading condition, shall also be considered to fill that hold upto the top of hatch coaming.

ρ_h = The density of cargo in a heavy bulk cargo loading condition.

h_c = Height from the load point to be actual cargo surface corresponding to the required cargo volume (max. heavy bulk cargo mass/ρ_h) and the angle of repose of the cargo.

H = height [m], from the load point to the top of hatch coaming.

M_h = maximum cargo mass [tonnes], to be carried in the hold under consideration when carrying heavy bulk cargo of density ρ_h [t/m^3].

h_c = height [m], from the load point to the actual cargo surface corresponding to the cargo volume (M_h/ρ_h) [m^3] in the hold and the angle of repose.

δ = angle of repose of bulk cargo in degrees, generally not to be taken greater than that given in Table 1.3.1:

Table 1.3.1 : Characteristics of select bulk cargoes

Bulk cargo	Angle of repose maximum [degrees]	Permea-bility μ minimum	Bulk density ρ_c [t/m^3]
Iron ore	35	0.3	3.0
Cement	25	0.3	1.3
Coal	20	0.3	0.9
Grain	20	0.5	0.8

1.3.2 In intact conditions, pressure at a load point on inner bottom and sloping or vertical bulkheads due to dry bulk cargo is to be taken as:

$\rho_c = C \cdot q\,(g_o + 0.5\,a_v)\,10^{-3}$ [N/mm^2]

where,

C = 1.0 for inner bottom

= $\tan^2(45 - \delta/2)$ for vertical bulkheads

= $\sin^2\alpha \cdot \tan^2(45 - \delta/2) + \cos^2\alpha$ for sloping bulkheads

α = angle of sloping bulkhead with the horizontal plane, [degrees]

$q = \rho_f \cdot H$ [t/m^2], or

$= \rho_h \cdot h_c$ [t/m^2]; whichever is greater.

g_o = 9.81 [m/s^2]

a_v = vertical acceleration [m/s^2] as given in Pt.3, Ch.4, Sec.2.3.

1.3.3 The design loads for hold-flooded conditions, when required, are to be taken as per Table 1.3.3 and Fig.1.3.3.

In this context, the flooded waterline is to be considered at a distance d_f [m] measured vertically above the baseline with the ship in upright position.

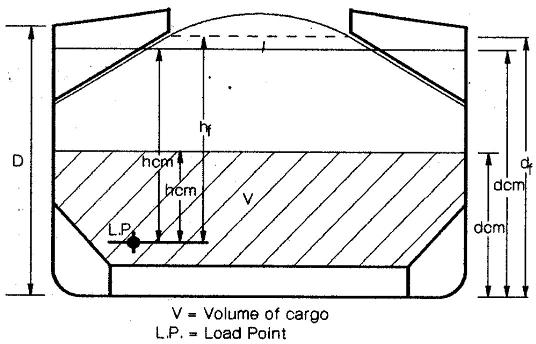


Fig.1.3.3 : Definition of d_f, h_f, d_{cm} and h_{cm}

d_f is taken as follows:

a) For bulk carriers in general

- D [m] for the foremost hold and for the transverse bulkhead between the two foremost holds
- 0.9D [m] for other holds and for other transverse bulkheads.

b) For bulk carriers which have been assigned type B-0 freeboard and are of DWT < 50,000 [tonnes]

- 0.95D [m] for the foremost hold and for the transverse bulkhead between the two foremost holds
- 0.85D [m] for the other holds and for other transverse bulkheads.

1.3.4 Where the ship is to carry cargoes having bulk density less than 1.78 [t/m^3], in non-homogeneous condition, the distance d_f in (a) and (b) above may be reduced by 0.05D.

Table 1.3.3 : Design loads on bulkheads in flooded conditions (See Note 1)

Condition		Pressure, $p_{c,f}$ at a load point on sloping or vertical bulkheads [N/mm²]	Total force, on a corrugation [kN]
I.	Flooding of a hold already loaded with bulk cargo		
	a) When the flooded waterline is above the mean plane of cargo in hold surface i.e. when $d_f \ge d_1$	i) for load points located above the mean plane of cargo surface $p_{c,f} = 0.01\ h_f$	$F_{c,f} = \frac{s}{2}[0.01(d_f - d_{cm})^2$ $+\{0.01(d_f - d_{cm})$ $+(p_{c,f})_{le}\}(d_{cm} - d_{le})]$
		ii) for load points located below the mean plane of cargo surface in hold $p_{c,f} = 0.01\ h_f + [g_o\ .\ \rho_c - 10\ (1 - \mu)]\ h_{cm}.C.10^{-3}$	
	b) When the flooded waterline is below the mean plane of cargo surfaces in a hold i.e. when $d_f < d_1$	i) for load points located above the flooded waterline $p_{c,f} = \rho_c\ .\ g_o\ .h_{cm}.C.10^{-3}$	$F_{c,f} = \frac{s}{2}[\rho_c\ .g_o.C\ (d_{cm} - d_f)^2$ $-10^{-3} + \{\rho_c .g_o.C\ (d_{cm} - d_f)$ $10^{-3} + (p_{c,f})_{le}\}(d_f - d_{le})]$
		ii) for load points located below the flooded waterline $p_{c,f} = 0.01 h_f + [g_o\ .\rho_c\ .$ $h_{cm} - 10(1 - \mu)\ h_f\ ].C.10^{-3}$	
II.	Flooding of an empty hold	$p_f = 0.01\ h_f$	$F_f = 0.005\ .\ s\ .\ (d_f - d_{le})^2$
III.	Hold (loaded with bulk cargo) adjacent to the flooded hold	For calculation of the resultant loads in flooded conditions in homogeneous mode as per 2.10.7	
		$p_c = \rho_c\ .g_o\ .h_{cm}\ .C.10^{-3}$	$F_c = 0.5\ \rho_c\ .g_o\ .s\ .C.$ $(d_{cm} - d_{le})^2\ .\ 10^{-3}$

d_f = as defined in 1.3.3 and where applicable, reduced as per 1.3.4

ρ_c = density [t/m³] of the bulk cargo in the hold. Unless the ship is designed to carry, in non-homogeneous conditions, only iron ore or cargo of bulk density equal to or greater than 1.78 [t/m³], the maximum mass of cargo which may be carried in the hold shall also be considered to fill that hold up to the top of hatch coaming. Also see Table 1.3.1.

h_f = distance [m] from the load point to the flooded waterline

h_{cm} = distance [m] from the load point to the mean plane of cargo surface

μ = permeability of the bulk cargo considered, also see Table 1.3.1

d_{cm} = distance of mean plane of cargo surface from base line [m] see Fig.1.3.3

d_{le} = distance of lower end of bulkhead, from base line [m]

= sum of height of the double bottom 'h_{DB}' and the mean height of lower stool 'h_{LS}'

s = corrugation spacing [mm], S_1 as indicated in Fig.2.9.1

Note 1 : Most severe combinations of cargo induced loads and flooding loads are to be determined and used. See 2.10.4.

1.4 Requirements for the fitting of a forecastle for bulk carriers, ore carriers and combination carriers

1.4.1 All vessels with any of the following class notations are to be fitted with an enclosed forecastle on the freeboard deck as detailed in 1.4.2 :

'BULK CARRIER'
BULK CARRIER "Strengthened for heavy cargoes"
BULK CARRIER "Strengthened for heavy cargoes, hold(s) …. may be empty"
'ORE CARRIER', 'ORE OR OIL CARRIER', 'OIL OR BULK CARRIER'.

1.4.2 The forecastle is to be located on the freeboard deck with its aft bulkhead fitted in way or aft of the collision bulkhead as shown in Fig.1.4.2.

However, if this requirement hinders hatch cover operation, the aft bulkhead of the forecastle may be fitted forward of the forward bulkhead of the foremost cargo hold provided the forecastle length is not less than 7% of ship length abaft the forward perpendicular where the ship length and forward perpendicular are defined in the International Convention on Load Line 1966 and its Protocol 1988.

The forecastle height H_F above the main deck is to be not less than:

- the standard height of a superstructure as specified in the International Convention on Load Line 1966 and its Protocol of 1988, or

- H_c + 0.5 [m], where H_c is the height of the forward transverse hatch coaming of the foremost cargo hold

whichever is the greater.

1.4.3 Reduced horizontal loading on the forward transverse hatch coaming and hatch cover of the foremost cargo hold as per 5.4.1 and 5.5.2 due to the shielding effect provided by the forecastle, can be considered only for all points of the aft edge of the forecastle deck:

$$l_F \leq 5\sqrt{H_F - H_c}$$

where,

l_f, H_F and H_c are as shown in Fig.1.5.2.

1.4.4 A breakwater is not to be fitted on the forecastle deck with the purpose of protecting the hatch coaming or hatch covers. If fitted for other purposes, it is to be located such that its upper edge at centre line is not less than H_B / tan 20° forward of the aft edge of the forecastle deck, where H_B is the height of the breakwater above the forecastle (See Fig.1.4.2).

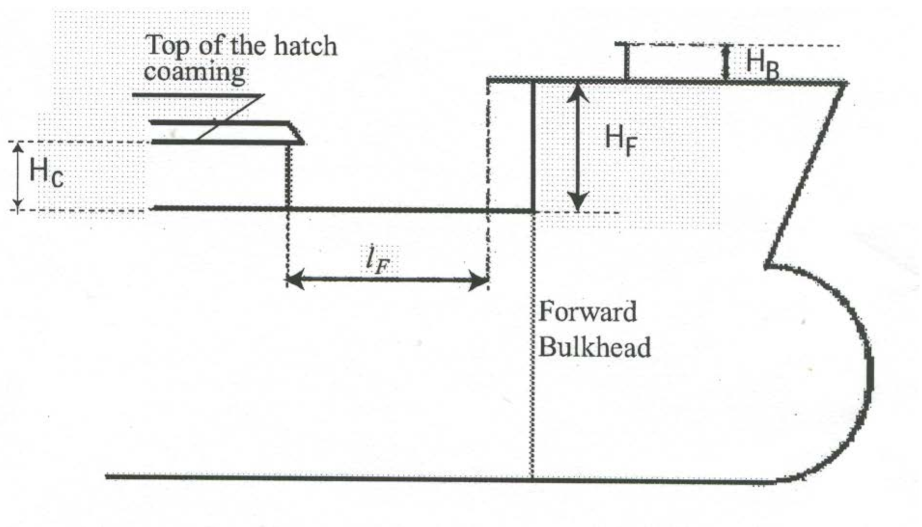


Fig.1.4.2

1.5 Arrangements for access in the cargo area and forward spaces

1.5.1 The requirements in 1.5 and 1.6 apply to bulk carriers of single or double side skin construction, with double bottom, hopper side tanks and top side tanks fitted below the upper deck, ore carriers and combinations carriers of 20,000 gross tonnage and over.

1.5.2 Each space is to be provided with a means of access to enable, throughout the life of the ship, overall and close-up inspections and thickness measurements of the ship's structures. Such means of access are to comply with the requirements of the Technical provisions for means of access for inspections, specified in 1.6

Where a permanent means of access may be susceptible to damage during normal cargo loading and unloading operations or where it is impracticable to fit permanent means of access, the provision of movable or portable means of access, as specified in 1.6 may be considered, provided that the means of attaching, rigging, suspending or supporting the portable means of access forms a permanent part of the ship's structure. All portable equipment may be capable of being readily erected or deployed by ship's personnel.

Each space for which close-up inspection is not required such as fuel oil tanks and void spaces forward of cargo area, may be provided with a means of a access necessary for overall survey intended to report on the overall conditions of the hull structure.

1.5.3 The construction and materials of all means of access and their attachment to the ship's structure are to be approved by IRS.

1.5.4 Access to cargo holds, cofferdams, ballast tanks and other spaces in the cargo area is to be direct from the open deck and such as to ensure their complete inspection. Access to double bottom spaces or to forward ballast tanks may be from a pipe tunnel, cargo hold, double hull space or similar compartment not intended for the carriage of hazardous cargoes. Access to a double side skin spaces may be from a topside tank or double bottom tank.

1.5.5 Tanks and subdivisions of tanks, having a length of 35 [m] or more are to be fitted with at least two access hatchways and ladders, as far apart as practicable. Tanks less than 35 [m] in length is to be served by at least one access hatchway and ladder. When a tank is subdivided by one or more swash bulkheads or similar obstructions which do not allow ready means of access to the other parts of the tank, at least two hatchways and ladders are to be fitted.

1.5.6 Each cargo hold is to be provided with at least two means of access as far apart as practicable. In general, these accesses should be arranged diagonally, for example one access near the forward bulkhead on the port side, the other one near the aft bulkhead on the starboard side.

1.5.7 For access through horizontal openings, hatches or manholes, the dimensions are to be sufficient to allow a person wearing a self-contained air-breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space.

1.5.8 A ship's means of access to carry out overall and close-up inspections and thickness measurements is to be described in a Ship Structure Access Manual which is to consist of two parts.

The first part should include the following for each space:

a) plans showing the means of access to the space, with appropriate technical specifications and dimensions;

b) plans showing the means of access within each space to enable an overall inspection to be carried out, with appropriate technical specifications and dimensions. The plans are to indicate from where each area in the space can be inspected;

c) plans showing the means of access within the space to enable close-up inspection to be carried out, with appropriate technical specifications and dimensions. The plans are to indicate the positions of critical structural areas, whether the means of access is permanent or portable and from where each area can be inspected. Critical structural areas are to be identified by advanced calculation techniques for structural strength and fatigue performance, and service history of similar ships;

d) instructions for regularly inspecting and maintaining the structural strength of all means of access and means of attachment, taking into account any corrosive atmosphere that may be within the space;

e) instructions for safety guidance when rafting is used for close-up inspections and thickness measurements;

f) instructions for the rigging and use of any portable means of access in a safe manner;

g) an inventory of all portable means of access; and

The second part of the Ship Structure Access Manual is to contain a form of record of periodical inspections and maintenance, and change of inventory of portable equipment due to additions or replacement after construction. The format of this part is to be approved at the time of construction of the ship. The manual is to include a re-approval procedure for any changes to the permanent, portable or movable means of access.

The Ship Structure Access Manual is to be approved by IRS and an updated copy including all revisions / re-approvals is to be kept onboard.

1.6 Technical provisions for means of access for inspections

1.6.1 **Definitions** : For the purpose of these technical provisions, the following definitions apply:

a) **Rung** means the step of vertical ladder or step on the vertical surface.

b) **Tread** means the step of inclined ladder, or step for the vertical access opening.

c) **Flight of an inclined ladder** means the actual stringer length of an inclined ladder. For vertical ladders, it is the distance between the platforms.

d) **Stringer** means:

i) the frame of a ladder; or

ii) the stiffened horizontal plating structure fitted on side shell, transverse bulkheads and/or longitudinal bulkheads in the space. For the purpose of ballast tanks of less than 5 [m] width forming double side spaces, the horizontal plating structure is credited as a stringer and a longitudinal permanent means of access, if it provides a continuous passage of 600 [mm] or more in width past frames or stiffeners on the side shell or longitudinal bulkhead. Openings in stringer plating utilized as permanent means of access are to be arranged with guard rails or grid covers to provide safe passage on the stringer or safe access to each transverse web.

e) **Vertical ladder** means a ladder of which the inclined angle is 70° and over up to 90°. A vertical ladder is not to be skewed by more than 2°.

f) **Overhead obstructions** mean the deck or stringer structure including stiffeners above the means of access.

g) **Distance below deck head** means the distance below the plating.

h) **Cross deck** means the transverse area which is located inboard of the line of hatch openings of the main deck and between adjacent transverse hatch coamings.

1.6.2 Structural members subject to the close-up inspections and thickness measurements of the ship's structure referred to in Pt.1, Ch.2, except those in double bottom spaces, are to be provided with a permanent means of access to the extent as specified in Table 1.6.2(a) and Table 1.6.2(b), as applicable. For wing ballast tanks of ore carriers, approved alternative methods such as rafting may be used in combination with the fitted permanent means of access, provided that the structure allows for its safe and effective use.

1.6.3 Permanent means of access should as far as possible be integral to the structure of the ships, thus ensuring that they are robust and at the same time contributing to the overall strength of the structure of the ship.

Table 1.6.2a : Means of access to ballast tanks in bulk carriers*
Top side tanks 1.1 For each topside tank of which the height is 6 [m] and over, one longitudinal continuous permanent means of access shall be provided along the side shell webs and installed at a minimum of 1.6 [m] to a maximum of 3 [m] below deck with a vertical access ladder in the vicinity of each access to that tank. 1.2 If no access holes are provided through the transverse webs within 600 [mm] of the tank base and the web frame rings have a web height greater than 1 [m] in way of side shell and sloping plating, then stop rings/grab rails shall be provided to allow safe access over each transverse web frame ring. 1.3 Three permanent means of access, fitted at the end bay and middle bay of each tank, shall be provided spanning from tank base up to the intersection of the sloping plate with the hatch side girder. The existing longitudinal structure, if fitted on the sloping plate in the space may be used as part of this means of access. If the longitudinal structures on the sloping plate are fitted outside of the tank a means of access is to be provided. 1.4 For topside tanks of which the height is less than 6 [m], alternative means as defined in 1.6.10 of the technical provisions or a portable means may be utilized in lieu of the permanent means of access.
Bilge hopper tanks 1.5 For each bilge hopper tank of which the height is 6 [m] and over, one longitudinal continuous permanent means of access shall be provided along the side shell webs and installed at a minimum of 1.2 [m] below the top of the clear opening of the web ring with a vertical access ladder in the vicinity of each access to the tank. Note: The height of a bilge hopper tank located outside of the parallel part of vessel is to be taken as the maximum of the clear vertical distance measured from the bottom plating to the hopper plating of the tank. 1.5.1 An access ladder between the longitudinal continuous permanent means of access and the bottom of the space shall be provided at each end of the tank. 1.5.2 Alternatively, the longitudinal continuous permanent means of access can be located through the upper web plating above the clear opening of the web ring, at a minimum of 1.6 [m] below the deck head, when this arrangement facilitates more suitable inspection of identified structurally critical areas. An enlarged longitudinal frame of at least 600 [mm] clear width can be used for the purpose of the walkway. The foremost and aftermost bilge hopper ballast tanks with raised bottom of which the height is 6 [m] and over, a combination of transverse and vertical means of access for access to the sloping plate of hopper tank connection with side shell plating for each transverse web can be accepted in place of the longitudinal permanent means of access.

Table 1.6.2a (Contd.)

1.5.3 For double side skin bulk carriers the longitudinal continuous permanent means of access may be installed within 6 [m] from the knuckle point of the bilge, if used in combination with alternative methods to gain access to the knuckle point.

1.6 If no access holes are provided through the transverse ring webs within 600 [mm] of the tank base and the web frame rings have a web height greater than 1 [m] in way of side shell and tank base, then step rungs/grab rails are to be provided to allow safe access over each transverse web frame ring.

1.7 For bilge hopper tanks of which the height is less than 6 [m], alternative means as defined in 1.6.10 or a portable means may be utilized in lieu of the permanent means of access. It is to be demonstrated that such means of access can be deployed and made readily available in the areas where needed.

Double skin side tanks

1.8 Permanent means of access is to be provided in accordance with the applicable sections of Pt.5, Ch.2, Table 2.4.2.

Fore peak tanks

1.9 For fore peak tanks with a depth of 6 [m] or more at the centre line of the collision bulkhead, a suitable means of access shall be provided for access to critical areas such as the underdeck structure, stringers, collision bulkhead and side shell structure.

1.9.1 Stringers of less than 6 [m] in vertical distance from the deck head or a stringer immediately above are considered to provide suitable access in combination with portable means of access.

1.9.2 In case the vertical distance between the deck head and stringers, stringers or the lowest stringer and the tank bottom is 6 [m] or more, alternative means of access as defined in 1.6.10 is to be provided.

Table 1.6.2b : Means of access to cargo holds of bulk carriers*

Access to underdeck structure

1.1 Permanent means of access is to be fitted to provide access to the overhead structure at both sides of the cross deck and in the vicinity of the centerline. Each means of access is to be accessible from the cargo hold access mentioned in 1.5.6 or directly from the main deck and installed at a minimum of 1.6 [m] to a maximum of 3 [m] below the deck. Means of access is to be provided to the cross deck structures of the foremost and aftermost part of the cargo hold.

1.2 An athwartship permanent means of access fitted on the transverse bulkhead at a minimum 1.6 [m] to a maximum 3 [m] below the cross-deck head is accepted as equivalent to 1.1

1.3 Access to the permanent means of access to overhead structure of the cross deck may also be via the upper stool.

1.4 Ships having transverse bulkheads with full upper stools (extending between top side tanks and upto the hatch end beam) with access from the main deck which allows monitoring of all framing and plates from inside, do not require permanent means of access of the cross deck.

1.5 Special attention is to be paid to the structural strength where any access opening is provided in the main deck or cross deck. The requirements for access to cross deck structure are also applicable to ore carriers.

1.6 Alternatively, movable means of access may be utilized for access to the overhead structure of cross deck if its vertical distance is 17 [m] or less above the tank top. This movable means of access need not be necessarily be carried on board the vessel, but is to be made available when required.

Access to vertical structures

1.7 Permanent means of vertical access shall be provided in all cargo holds and built into the structure to allow for an inspection of a minimum of 25% of the total number of hold frames port and starboard equally distributed throughout the hold including at each end in way of transverse bulkheads. But in no circumstance shall this arrangement be less than 3 permanent means of vertical access fitted to each side (fore and aft ends of hold and mid-span). Permanent means of vertical access fitted between two adjacent hold frames is counted for an access for the inspection of both hold frames. A means of portable access may be used to gain access over the sloping plating of lower hopper ballast tanks.

1.8 In addition, portable or movable means of access are to be utilized for access to the remaining hold frames upto their upper brackets and transverse bulkheads.

1.9 Portable or movable means of access may be utilized for access to hold frames upto their upper bracket in place of the permanent means required in 1.6. These means of access are to be carried on board the ship and able to be transported to location in cargo hold and safely erected by ship’s staff.

1.10 The width of vertical ladders for access to hold frames is to be at least 300 [mm], measured between stringers.

1.11 A single vertical ladder over 6 [m] in length is acceptable for the inspection of the hold side frames in a single skin construction.

1.12 For double side skin construction no vertical ladders for the inspection of the cargo hold surfaces are required. Inspection of this structure should be provided from within the double hull space.

1.6.4 Elevated passageways forming sections of a permanent means of access, where fitted, is to have a minimum clear width of 600 [mm], except for going around vertical webs where the minimum clear width may be reduced to 450 [mm] and have guard rails over the open side/ sides of their entire length. Sloping structures that are sloped 5 degree or more from horizontal plane, providing part of the access is to be of a non-skid construction. Non-skid construction is to be such that the surface on which the personnel walks provides sufficient friction to the sole of boots even when the surface is wet and covered with thin sediment.

Guard rails are to be atleast 1000 [mm] in height and consist of a rail and an intermediate rail. Guard rails are to be fitted on the open side. For stand alone passageways guard rails are to be fitted on both sides of these structures. Guardrail stanchions are to be attached to the permanent means of access. The distance between the passageway and the intermediate rail and the distance between intermediate rail and the top rail shall not be more than 500 [mm]. They are to be of substantial construction ensuring adequate design strength as well as residual strength during service life. Stanchions are to be not more than 3 [m] apart. Discontinuous handrails are allowed provided the gap does not exceed 50 [mm]. (See Fig.1.6.4). The distance between adjacent stanchions across the handrail gaps is to be not more than 350 mm.

Durability of passage ways and guard rails are to be ensured by corrosion protection and inspection and maintenance during services. Fire resistant materials are to be used for all means of access.

1.6.5 Access to permanent means of access and vertical openings from the ship's bottom is to be provided by means of easily accessible passageways, ladders or treads. Treads are to be provided with lateral support for the foot. Where the rungs of ladders are fitted against a vertical surface, the distance from the centre of the rungs to the surface is to be at least 150 [mm]. Where vertical manholes are fitted higher than 600 [mm] above the walking level, access is to be facilitated by means of treads and hand grips with platform landings on both sides. In such cases, it is to be demonstrated that an injured person can be easily evacuated.

* For ore carriers, permanent means of access shall be provided in accordance with the applicable sections of Table 1.6.2 and Pt.5, Ch.2, Table 2.4.2(a) and Table 2.4.2(b).

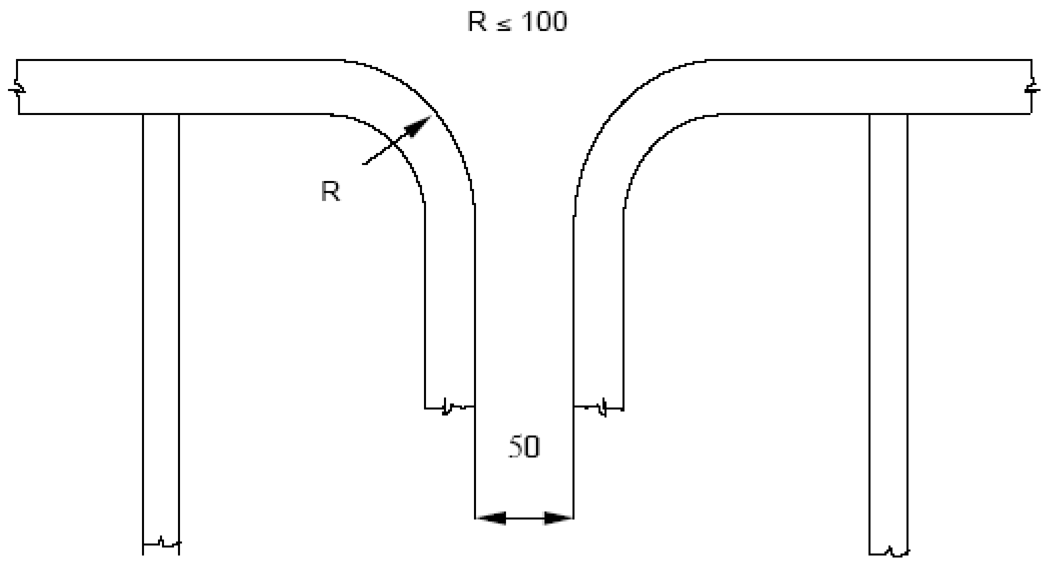


Fig.1.6.4

1.6.6 Permanent inclined ladders are to be inclined at an angle of less than 70°. There are to be no obstructions within 750 [mm] of the face of the inclined ladder, except that in way of an opening this clearance may be reduced to 600 [mm]. The clearance distances are to be measured perpendicular to the face of the ladder. Resting platforms of adequate dimensions are to be provided normally at a maximum of 6 [m] vertical height. Requirements for resting platforms are to be similar to that of elevated passageways.
Ladders and handrails are to be constructed of steel or equivalent material of adequate strength and stiffness and securely attached to the structure by stays. The method of support and length of stay are to be such that vibration is reduced to a practical minimum. In cargo holds, ladders are to be designed and arranged so that cargo handling difficulties are not increased and the risk of damage from cargo handling gear is minimized.

1.6.7 The width of inclined ladders between stringers are not to be less than 400 [mm] in general. However, the width of inclined ladders for access to a cargo hold is to be at least 450 [mm]. The treads are to be equally spaced at a distance apart, measured vertically, of between 200 [mm] and 300 [mm]. When steel is used, the treads are to be formed of two square bars of not less than 22 [mm] by 22 [mm] in section, fitted to form a horizontal step with the edges pointing upward. The treads are to be carried through the side stringers and attached thereto by double continuous welding. All inclined ladders are to be provided with two course handrails of substantial construction on both sides, fitted at a convenient distance above the treads. Vertical height of handrails is not to be less than 890 [mm] from the center of the step and two course handrails need only be provided where the gap between stringer and top handrail is greater than 500 [mm].

1.6.8 For vertical ladders or spiral ladders, the width and construction should be in accordance with accepted international or national standards.
The width of vertical ladders is to be not less than 350 [mm] and the vertical distance between the rungs is to be between 250 [mm] and 350 [mm]. The minimum climbing clearance in width is to be 600[mm] other than for ladders between hold frames.
The vertical ladders are to be secured at intervals not exceeding 2.5 [m] apart to prevent vibration.

1.6.9 No free-standing portable ladder is to be more than 5 [m] long. Mechanical devices such as hooks for securing the upper end of a ladder is considered as an appropriate securing device if movement fore/ aft and sideways can be prevented at the upper end of the ladder.

1.6.10 Alternative means of access include, but are not limited to such devices as:

a) hydraulic arm fitted with a stable base;
b) wire lift platform;
c) staging;
d) rafting;
e) robot arm or remotely operated vehicle (ROV);
f) portable ladders (ladders more than 5 [m] long shall only be utilized if fitted with a mechanical device to secure the upper end of the ladder);
g) other means of access, approved by and acceptable to IRS.

(Refer to Classification Notes : “Guidelines for approval / acceptance of alternative means of access to spaces in oil tankers, bulk carriers, ore carriers and combination carriers”).

Means for safe operation and rigging of such equipment to and from and within these spaces are to be clearly described in the Ship Structure Access Manual.

1.6.11 For access through horizontal openings, hatches or manholes, the minimum clear opening is not to be less than 600 [mm] x 600 [mm], which may have corner radii of not more than 100 [mm]. Where a larger corner sections is desired to reduce the stress level around the opening, the size of the opening is to be suitably increased to ensure the required size of clear opening e.g. 600 [mm] x 800 [mm] opening with 300 [mm] corner radius is acceptable.

When access to a cargo hold is arranged through the cargo hatch, the top of the ladder is to be placed as close as possible to the hatch coaming.

Access hatch coamings having a height greater than 900 [mm] shall also have steps on the outside in conjunction with the ladder.

1.6.12 For access through vertical openings, or manholes, in swash bulkheads, floors, girders and web frames providing passage through the length and breadth of the space, the minimum opening is to be not less than 600 [mm] x 800 [mm] at a height of not more than 600 [mm] from the passage unless gratings or other foot holds are provided.

The opening of 600 [mm] x 800 [mm] may have corner radii of 300 [mm]. An opening of 600 [mm] in height x 800 [mm] in width may be accepted as access opening in vertical structures where it is not desirable to make large opening considering structural strength aspects, such as in girders and floors in double bottom tanks.

Subject to verification of easy evacuation of injured person on a stretcher, a vertical opening 850[mm] x 620 [mm] as shown in Fig.1.6.12 is considered as an acceptable alternative to the opening of 600 [mm] width x 800 [mm] height with corner radii of 300 [mm].

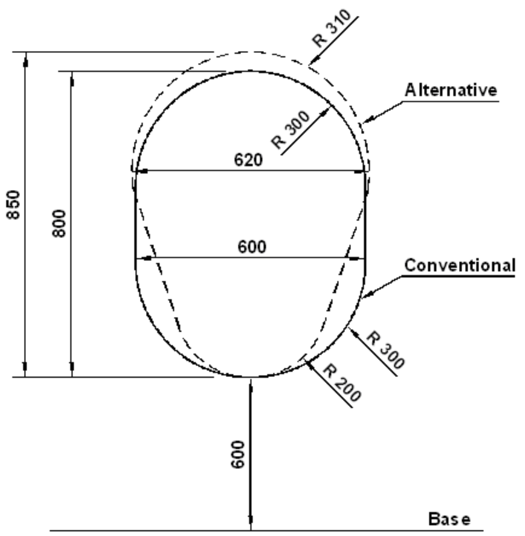


Fig.1.6.12 : Access opening in vertical structure

1.6.13 Access ladders to cargo holds and other spaces are to be as follows:

a) Where the vertical distance between the upper surface of adjacent decks or between deck and the bottom of the cargo space is not more than 6 [m], either a vertical ladder or an inclined ladder or a combination of both.

b) Where the vertical distance between the upper surface of adjacent decks or between deck and the bottom of the cargo space is more than 6 [m], an inclined ladder or series of inclined ladders at one end of the cargo hold, except the uppermost 2.5 [m] of a cargo space measured clear of overhead obstructions and the lowest 6 [m] may have vertical ladders, provided that the vertical extent of the inclined ladder or ladders connecting the vertical ladders is not less than 2.5 [m].

   The second means of access at the other end of the cargo hold may be formed of a series of staggered vertical ladders, which should comprise of one or more ladders linking platforms spaced not more than 6 [m] apart vertically and displaced to one side of the ladder. Adjacent sections of ladder should be laterally offset from each other by at least the width of the ladder. The uppermost entrance section of the ladder directly exposed to a cargo hold should be vertical for a distance of 2.5 [m] measured clear of overhead obstructions and connected to a ladder-linking platform.

c) A vertical ladder may be used as a means of access to topside tanks, where the vertical distance is 6 [m] or less between the deck and the longitudinal means of access in the tank or the stringer or the bottom of the space immediately below the entrance. The uppermost entrance section from deck of the vertical ladder of the tank should be vertical for a distance of 2.5 [m] measured clear of the overhead obstructions and comprises a ladder linking platform unless landing on the longitudinal means of access, the stringer or the bottom within the vertical distance. The platform is to be displaced to one side of a vertical ladder.

d) Unless allowed in c) above, an inclined ladder or combination of ladders should be used for access to a tank or a space where the vertical distance is greater than 6 [m] between the deck and a stringer immediately below the entrance, between stringers, or between the deck or a stringer and the bottom of the space immediately below the entrance.

   In such cases the uppermost entrance section from deck of the ladder should be vertical for a distance of 2.5 [m] clear of the overhead obstructions and connected to a landing platform and continued with an inclined ladder. The flights of inclined ladders are not be more than 9 [m] in actual length and the vertical height is not normally be more than 6 [m]. The lowermost section of the ladders may be vertical for a vertical distance of not less than 2.5 [m].

e) In spaces of less than 2.5 [m] width, the access to the space may be by means of vertical ladders that comprise of one or more ladder linking platforms spaced not more than 6 [m] apart vertically and displaced to one side of the ladder. Adjacent sections of ladder should be laterally offset from each other by at least the width of the ladder.

f) A spiral ladder is considered acceptable as an alternative for inclined ladders. In this case the spiral ladder may be continued in the uppermost 2.5 [m] and the change over to vertical ladder is not required.

1.6.14 The uppermost entrance section from weather deck of the vertical ladder providing access to a tank is to be vertical for a distance of 2.5 [m] measured clear of the overhead obstructions and comprise a ladder linking platform, displaced to one side of a vertical ladder. The vertical ladder can be between 1.6 [m] and 3 [m] below weather deck structure if it lands on a longitudinal or athwartship permanent means of access fitted within that range.

1.6.15 With respect to 1.6.13 b) and e), adjecent sections of vertical ladder need to be installed so that the following provisions are complied with:

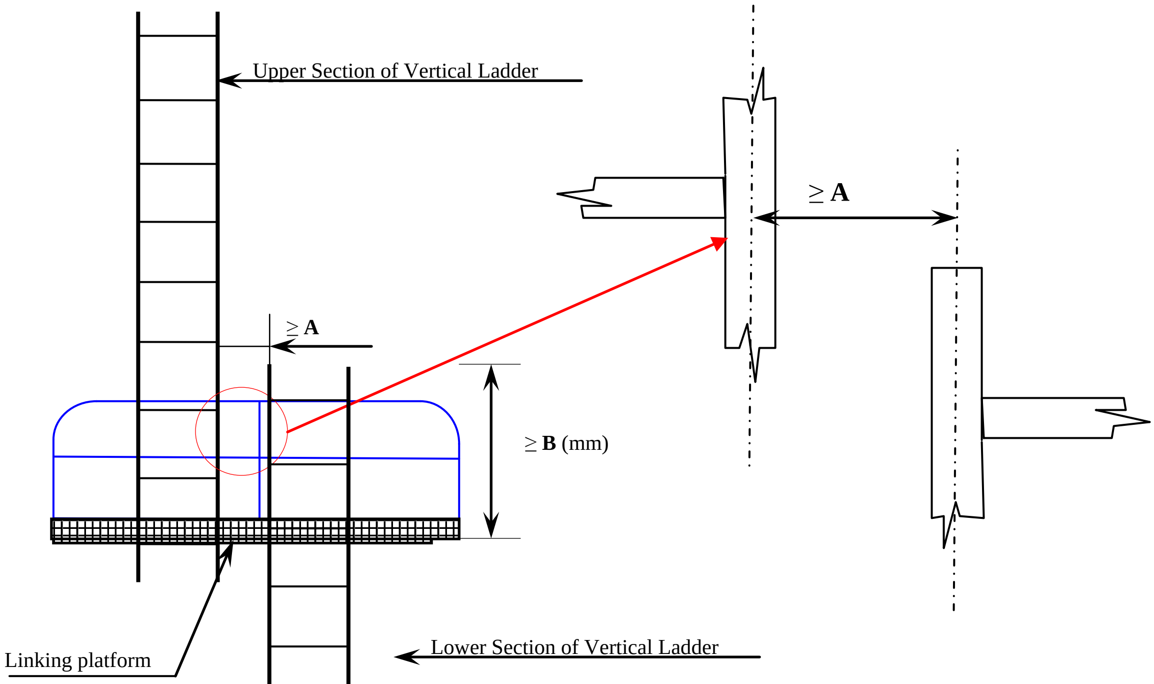
a) The minimum “lateral offset” , between two adjacent sections of vertical ladder, is the distance between the sections, upper and lower, so that the sdjecent stringers are spaced of at least 200 mm, measured from half thickness of each stringer.

b) Adjacent section is vertically overlapped, in respect to the lower end of the upper section, to a height of 1500 mm in order to permit a safe transfer between ladders.

c) no section of the access ladder is to be terminated directly or partly above an access opening.

Figure "A"

Vertical Ladder – Ladder through the linking platform



Dimension		
A	Horizontal separation between two vertical ladders, stringer to stringer	≥ 200 mm
B	Stringer height above landing or intermediate platform	≥ 1500* mm
C	Horizontal separation between ladder and platform	100 mm ≤ C< 300 mm
*Note: the minimum height of the handrail of resting platform is of 1000 mm (Technical Provision, resolution MSC.158(78), paragraph 3.3)		

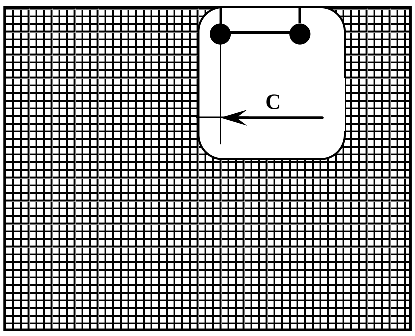
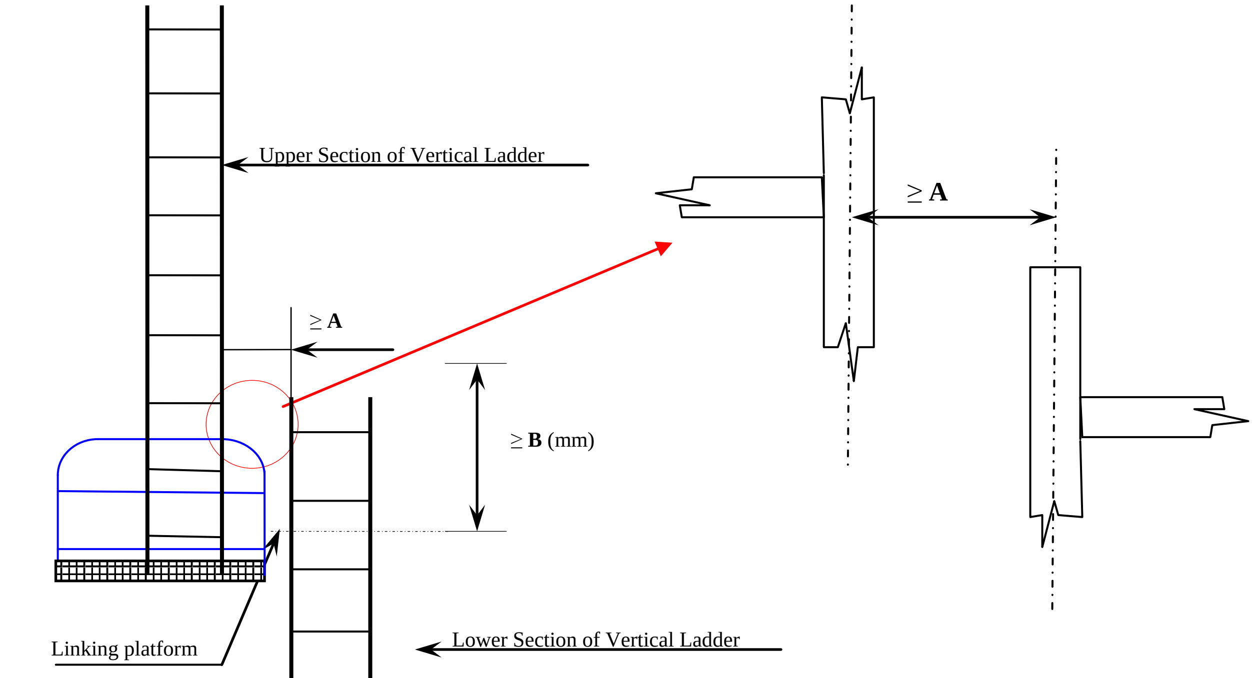
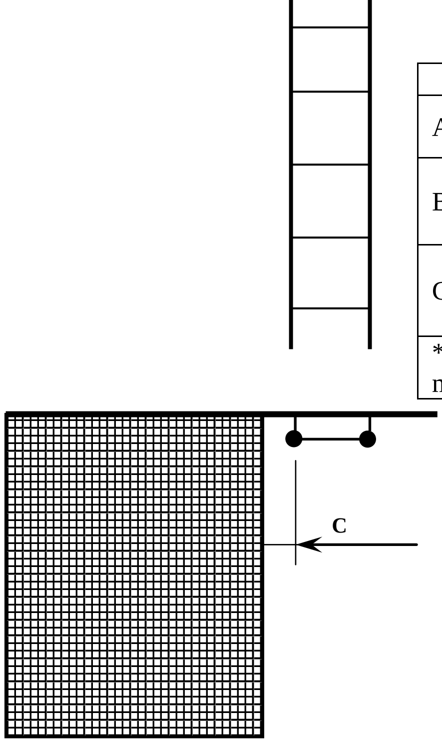


Figure "B"
Vertical Ladder – Side mount



Dimension		
A	Horizontal separation between two vertical ladders, stringer to stringer	≥ 200 mm
B	Stringer height above landing or intermediate platform	≥ 1500* mm
C	Horizontal separation between ladder and platform	100 mm ≤ C< 300 mm
*Note: the minimum height of the handrail of resting platform is of 1000 mm (Technical Provision, resolution MSC.158(78), paragraph 3.3)		



1.7 General requirements for double side skin construction

1.7.1 Bulk carriers of 150 [m] in length and above are to comply with the following in all areas of double side skin construction.

a) Primary stiffening structures of the double side skin shall not be placed inside the cargo hold space.

b) Subject to the provisions below, the distance between the outer shell and the inner shell at any transverse section shall not be less than 1000 [mm]. This distance is to be measured perpendicular to the outer shell from the top of the double bottom to the main deck, as indicated in Fig.1.7.1. The distance is to be maintained throughout the whole double-side skin construction.

The double side skin construction shall be such as to allow access for inspection as provided in regulation 1.6 and 1.7:

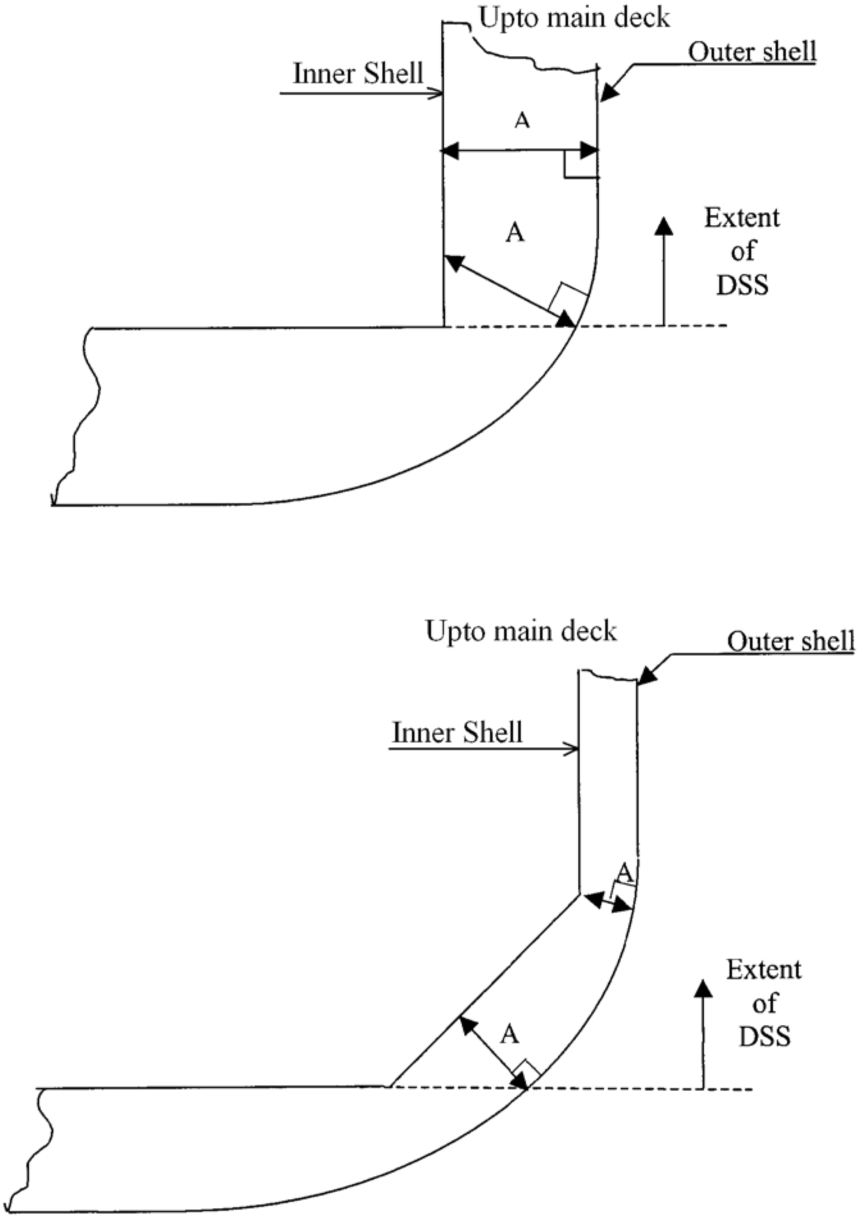
i) The clearances below need not be maintained in way of cross ties, upper and lower end brackets of transverse framing or end brackets of longitudinal framing.

ii) The minimum width of the clear passage through the double side skin space in way of obstructions such as piping or vertical ladders shall not be less than 600 [mm].

iii) Where the inner and/or outer skins are transversely framed, the minimum clearance between the inner surfaces of the frames shall not be less than 600 [mm].

iv) Where the inner and outer skins are longitudinally framed, the minimum clearance between the inner surfaces of the frames shall not be less than 800 [mm]. Outside the parallel part of the cargo hold length, this clearance may be reduced where necessitated by the structural configuration but in no case shall be less than 600 [mm].

i) The minimum clearance referred to above shall be the shortest distance measured between assumed lines connecting the inner surfaces of the frames on the inner and outer skins.



The value of A shall not be less than 1000mm

Fig.1.7.1 : Distance between inner and outer shell in way of double-side skin

Section 2

Bulk Carriers

2.1 Hull arrangement

2.1.1 Within the cargo region, longitudinal stiffening system, in general, is to be adopted for the double bottom, strength deck outside line of openings and in the hopper and topside tanks. Proposals for transverse framing on sloping bulkheads and side shell within the hopper side tanks and top side tanks will be specially considered.

2.1.2 In the hopper side tanks and top side tanks, tank end bulkheads or wash bulkheads are to be provided in line with the main hold bulkheads.

2.2 Longitudinal strength

2.2.1 The longitudinal strength in intact condition is to be in accordance with the requirements given in Pt.3 Ch.5.

2.2.2 Bulk carriers of the following configurations are to have sufficient strength to withstand flooding of each cargo hold in all cargo loading and ballast conditions:

a) Single side skin bulk carriers of length equal to or more than 150 [m] and designed to carry bulk cargoes having a density of 1000 [kg/m^3] and above.

b) Double side skin bulk carriers of length equal to or more than 150 [m] in which any part of the longitudinal bulkhead is located within B/5 or 11.5 [m] whichever is less, inboard from the ship's side at right angle to the centre line at the assigned summer load line, designed to carry bulk cargoes having a density of 1000 [kg/m^3] and above.

2.2.3 The longitudinal strength calculations in the flooded conditions are to be investigated for each of the seagoing cargo and ballast loading conditions and the still water bending moment and shear forces determined. Intermediate conditions of loading encountered during ballast water exchange need not be considered. Each cargo hold is to be considered individually flooded upto the equilibrium waterline.

2.2.4 For intact and flooded conditions featuring uneven distribution of cargo loading (e.g. loading conditions with empty holds or ballast conditions with ballast in cargo holds), shear force correction ΔQ_s as per Pt.3, Ch.5, Sec.4 is to be applied.

2.2.5 Calculation of the quantity of ingressed water due to flooding of the hold is to be based on the following assumptions:

c) The permeability of empty cargo spaces and the volume left in cargo spaces above any cargo is to be taken as 0.95.

ii) Appropriate permeability and bulk density is to be used for the cargo carried, See Table 1.3.1. In this context, the permeability means the ratio of the volume of the voids within the cargo mass to the volume occupied by the cargo. For packed cargo conditions, the permeability is to be assessed based on the actual cargo weight.

2.2.6 The hull girder section modulus and shear strength requirements for the flooded conditions at any location are to be calculated in a way similar to that for intact conditions (See Pt.3, Ch,5) considering the following:

- Maximum stillwater bending moment and shear force values in flooded conditions, at the section under consideration.

- The wave bending moment and wave shear force values for the flooded condition are to be assumed equal to 80% of the most probable maximum lifetime values given in Pt.3, Ch.5, Sec.2.2.

- The structure is assumed to remain fully effective in resisting the applied loading.

2.2.7 The buckling strength of the structure participating in longitudinal strength is to comply the requirements given in Pt.3, Ch.3.

2.3 Bottom structure - Scantlings and arrangements

2.3.1 The scantlings and arrangements are, in general, to be as per Pt.3, Ch.7, except as given below.

2.3.2 For bulk carriers with notation "Strengthened for heavy cargo" (with or without the additional empty hold notation) and for all ships in way of cargo hold(s) designated for ballast, the spacing of plate floors in the double bottom is generally not to exceed 2.5 [m].

2.3.3 The inner bottom plating is to be based on the design loads given in section 1.3.2 for intact conditions and 1.3.3 for hold flooded conditions. The permissible stress for hold flooded conditions is to be as per Pt.3, Ch.7, Table 4.2.1 using the value of f_B based on still water bending moment and wave bending moment in flooded conditions as given in 2.2.6.

For bulk carriers with notation “Strengthened for heavy cargo” (with or without the additional empty hold notation) or the thickness of inner bottom plating between the hopper or side tanks is not to be less than:

$t = (9.0 + 0.03L) \sqrt{k} + t_c$ [mm]

where, L need not be taken as greater than 200 [m].

2.3.4 The section modulus of inner bottom longitudinals is to be based on the design loads given in 1.4.2 for intact conditions and 1.4.3 for hold flooded conditions. For bulk carriers with notation “Strengthened for heavy cargo” (with or without the additional empty hold notation) the section modulus of both the bottom and inner bottom longitudinals (except in hopper side tanks) for intact conditions is to be obtained as per Pt.3, Ch.7, Sec.6.3 using permissible bending stress 'σ' value given below:

For bottom longitudinals in way of empty holds

$\sigma = (230 - 135\ f_{BH} - 0.7\ \sigma_{DBB})/k$ [N/mm^2]

For bottom longitudinals in way of loaded holds

$\sigma = (230 - 135\ f_{BS} - 0.7\ \sigma_{DBB})/k$ [N/mm^2]

For inner bottom longitudinals

$\sigma = (230 - 135\ f_{BH} \cdot f_z - 0.7\ \sigma_{DBI})/k$ [N/mm^2]

where,

f_z = as defined in Pt.3, Ch.7, Sec.1.2.

f_{BS}, f_{BH} = f_B as defined in Pt.3, Ch.7, Sec.1.2, but based on sagging and hogging values of (M_s + M_w) respectively, for the intact loading condition and location under consideration.

σ_{DBB}, σ_{DBI} = longitudinal stress in double bottom at middle of the hold found by direct analysis, at outer bottom plating and inner bottom plating respectively. For preliminary design consi-deration, σ_{DBB} and σ_{DBI} may be taken as:

= 60 [N/mm^2] in general

= 80 [N/mm^2], for ore loaded holds between adjacent empty holds.

The requirements for section modulus of inner bottom longitudinals for hold flooded conditions is to be similarly calculated. However, the permissible stress is to be obtained using the value of f_B based on SWBM and WBM in flooded conditions as per 2.2.6.

2.3.5 Structural details in way of double bottom tank and hopper tank knuckle is to be given special attention during design/fabrication.

In all dry holds where the double bottom tank and hopper tank knuckle is of radiused construction and the floor spacing is 2.5 [m] or greater, brackets as shown in Fig.2.3.5 are to be arranged mid-length between floors in way of the intersection. The brackets are to be attached to the adjacent inner bottom and hopper longitudinals. The thickness of the brackets is to be in accordance with Pt.3, Ch.7, Sec. 6.3.3 but need not exceed 15 [mm].

In way of floodable holds, two intermediate brackets as shown in Fig.2.3.5, are to be provided in all cases where the hopper to double bottom knuckle is radiused and one such intermediate bracket is to be provided where the double bottom tank and hopper tank knuckle is of welded construction.

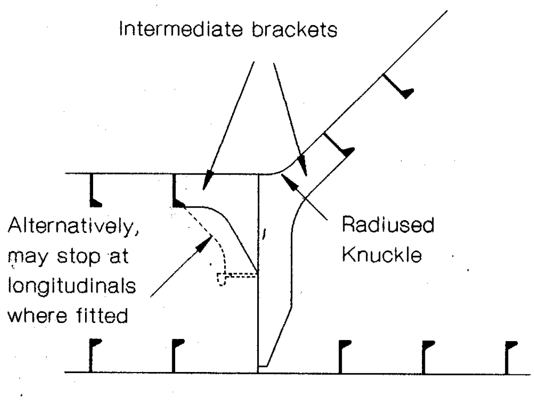


Fig.2.3.5 : Intermediate brackets at hopper/inner bottom interface

2.3.6 The connections at the knuckle are to be as follows:

a) Where of welded construction, the corner scallops in floors and transverses are to be omitted, or closed by welded collars where arranged for purposes of construction. In such cases, to ensure satisfactory welding of the collars, the radius of the scallops should not be less than 150 [mm]. See Fig.2.3.6(a). Alternatively, the scallop may be retained on the hopper tank side, provided gusset plates are arranged in line with the inner bottom plating. See Fig.2.3.6(b)

b) Where of radiused construction, the corner scallops are to be omitted, and full penetration welding arranged locally for the connection to the inner bottom plating. The centre of the flange at the knuckle is not to be greater than 70 [mm] from the side girder, See Fig.2.3.6(c).

2.4 Bottom structure - allowable hold loading considering hold flooding

2.4.1 These requirements apply to those bulk carriers which are required to be considered flooded for the hull girder longitudinal strength investigation in flooded conditions, as per 2.2.2.

The loading in each hold is not to exceed the allowable hold loading in flooded condition, which is to be calculated as per 2.4.6, using the loads given in 2.4.2 and the shear capacity of the double bottom obtained as per 2.4.3, 2.4.4 and 2.4.5.

In no case is the allowable hold loading, considering flooding, to be taken greater than the design hold loading in intact condition.

2.4.2 The loads to be considered as acting on the double bottom are those given by the external sea pressures and the combination of the cargo loads with those induced by the flooding of the hold to which the double bottom belongs.

The flooding head h_f is the distance, [m], measured vertically with the ship in the upright position, from the inner bottom to the flooded waterline as defined in 1.3.3 alone, i.e. without applying 1.3.4.

The most severe combinations of cargo induced loads and flooding loads are to be used, depending on the loading conditions included in the loading manual:

- homogeneous loading conditions;
- non homogeneous loading conditions;
- packed cargo conditions (such as steel mill products).

For each loading condition, the maximum bulk cargo density to be carried is to be considered in calculating the allowable hold loading limit.

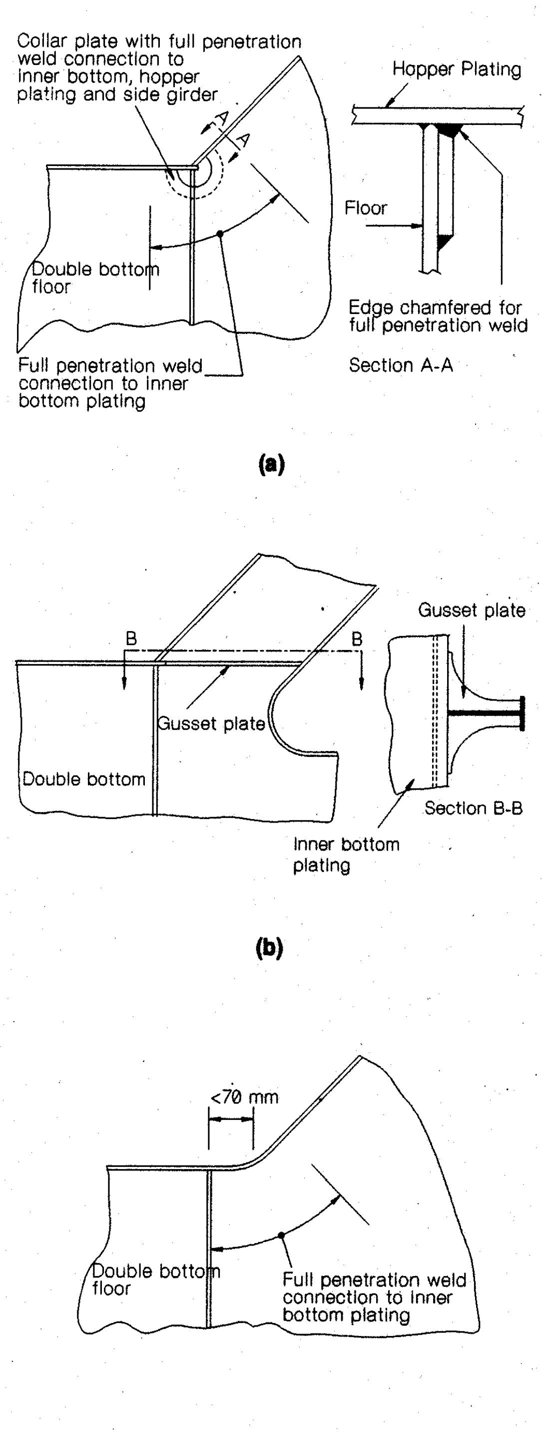


Fig.2.3.6 : Connection of intersection of inner bottom and hopper

2.4.3 The shear capacity C [kN] of the double bottom is defined as the sum of the shear strength at each end of:

- all floors adjacent to both hoppers, less one half of the strength of the two floors adjacent to each stool (or transverse bulkhead if no stool is fitted) (See Fig.2.4.3).

- all double bottom girders adjacent to both stools (or transverse bulkheads if no stool is fitted).

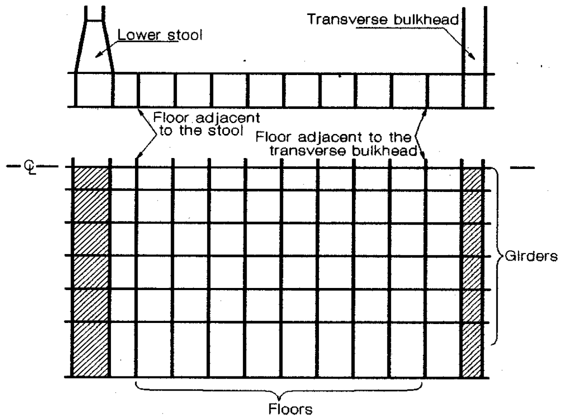


Fig.2.4.3 : Members contributing to shear capacity of double bottom

Where, in the end holds, girders or floors run out and are not directly attached to the boundary stool or hopper girder, their strength is to be evaluated for the one end only.

It may be noted that the floors and girders to be considered are those inside the hold boundaries formed by the hoppers and stools (or transverse bulkheads if no stool is fitted). The hopper side girders and the floors directly below the connection of the bulkhead stools (or transverse bulkheads if no stool is fitted) to the inner bottom are not to be included.

When the geometry and/or the structural arrangement of the double bottom are such as to make the above assumptions inadequate, the shear capacity C of double bottom will be specially considered.

In calculating the shear strength, the net thickness of floors and girders is to be used.

The net thickness, t_{net} = t - 2.5 [mm]

where,

t = thickness [mm], of floors and girders.

2.4.4 The floor shear strength in way of the floor panel adjacent to hoppers S_{f1} and the floor shear strength in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) S_{f2} are given by:

$$S_{f1} = A_f \cdot \frac{\tau_a}{\eta_1} \cdot 10^{-3} \ [kN]$$

$$S_{f2} = A_{fh} \cdot \frac{\tau_a}{\eta_2} \cdot 10^{-3} \ [kN]$$

where,

A_f = sectional area [mm^2], of the floor panel adjacent to hoppers;

A_{fh} = net sectional area [mm^2], of the floor panels in way of the openings in the outmost bay (i.e. that bay which is closer to hopper);

τ_a = allowable shear stress [N/mm^2]

$$= 162 \cdot \sigma_y^{\ 0.6} \cdot \left(\frac{t}{s}\right)^{0.8} \text{ or } \frac{\sigma_y}{\sqrt{3}};$$

whichever is lesser.

For floors adjacent to the stools or transverse bulkheads, τ_a may be taken as $\frac{\sigma_y}{\sqrt{3}}$

σ_y = minimum upper yield stress [N/mm^2], of the material;

s = spacing of stiffening members [mm], of panel under consideration;

η_1 = 1.10

η_2 = 1.20

η_2 may be reduced to 1.10 where adequate reinforcements are fitted in way of the openings in floors.

2.4.5 The girder shear strength in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted), S_{g1} and the girder shear strength in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g2} are given by:

$$S_{g1} = A_g \cdot \frac{\tau_a}{\eta_1} \cdot 10^{-3} \text{ [kN]}$$

$$S_{g2} = A_{gh} \cdot \frac{\tau_a}{\eta_2} \cdot 10^{-3} \text{ [kN]}$$

where,

A_g = minimum sectional area [mm^2], of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted).

A_{gh} = net sectional area, [mm^2], of the girder panel in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted).

τ_a = allowable shear stress, [N/mm^2], as given in 2.4.4.

η_1 = 1.10

η_2 = 1.15

η_2 may be reduced to 1.10 where adequate reinforcements are fitted in way of the openings in girders.

2.4.6 The allowable hold loading 'W', is given by:

$$W = \rho_c \cdot V \cdot \frac{1}{F} \text{ [t]}$$

where,

F = 1.1 in general 1.05 for steel mill products

ρ_c = maximum applicable value of bulk cargo density, [t/m^3] (See 2.4.2)

= cargo density for steel products.

V = volume, [m^3], of the hold under consideration upto a level, h_1 measured vertically above the inner bottom

$$h_1 = \frac{X}{\rho_c \cdot g_o} \text{ [m]}$$

X = the lesser of X_1 and X_2 for bulk cargoes

= X_1 for steel products

X_1 and X_2 are given below:

$$X_1 = \frac{Z + \rho \cdot g_o \cdot (E - h_f)}{1 - \frac{\rho}{\rho_c}(1-\mu)}$$

$X_2 = Z + \rho \cdot g_o (E - h_f \cdot \mu)$

$E = d_f - 0.1D$

d_f = as given in 1.3.3

μ = cargo permeability as per Table 1.3.1, however, need not be taken greater than 0.3. For steel mill products, μ = 0.

$Z = \frac{C_h}{A_{DB,h}}$ or $\frac{C_e}{A_{DB,e}}$ whichever is lesser.

where,

C_h = The shear capacity of the double bottom, [kN], considering, for each floor, the lesser of the shear strengths S_{f1} and S_{f2} and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2}. (See 2.4.3, 2.4.4 and 2.4.5).

C_e = The shear capacity of the double bottom, [kN], considering, for each floor, the shear strength S_{f1} and for each girder, the lesser of the shear strengths S_{g1} and S_{g2}. (See 2.4.3, 2.4.4 and 2.4.5).

$$A_{DB,h} = \sum_{i=1}^{i=n} S_i \cdot B_{DB,i}$$

$$A_{DB,e} = \sum_{i=1}^{i=n} S_i \cdot (B_{DB} - s_l)$$

n = number of floors between stools (or transverse bulkheads, if no stool is fitted)

S_i = mean spacing of i[th] floor [m]

$B_{DB,i}$ = (B_{DB} – s_l) - for floors whose shear strength is given by S_{f1} i.e. floors without openings in the outmost bay

= $B_{DB,h}$ - for floors whose shear strength is given by S_{f2} i.e. floors with openings in the outmost bay

B_{DB} = breadth of double bottom, [m], between hoppers (See Fig.2.4.6)

$B_{DB,h}$ = distance [m] between the two openings considered (See Fig.2.4.6)

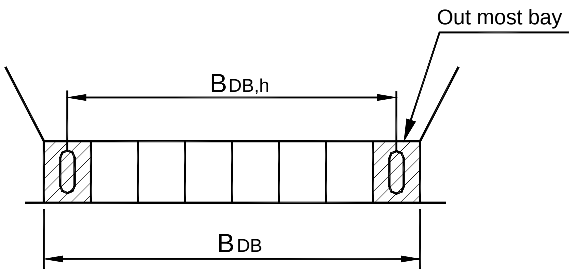


Fig.2.4.6 : Definition of B_{DB} and $B_{DB,h}$

s_l = spacing [m], of double bottom longitudinals adjacent to hoppers.

2.5 Side structure

2.5.1 The requirements given in this section apply to the side structures of cargo holds bounded by the side shell only of all bulk carriers which are contracted for construction on or after 1 July 1998.

2.5.2 The thickness of the side shell plating located between the hopper and topside tanks is to be not less than:

$$t = \sqrt{L} \quad [mm]$$

2.5.3 The thickness of web of main frames situated within cargo and ballast holds, except in the foremost hold, is not to be less than:

$$t = (7.0 + 0.03L) \ [mm]$$

where, L need not be taken as greater than 200 [m].

In foremost hold, the frame web thickness is to be at least 15% greater than that given above.

The thickness of the main frame lower bracket is to be 2 [mm] greater than the minimum frame web thickness. In no case the thickness of the main frame lower brackets and upper brackets is to be less than that provided for main frame web.

2.5.4 Frames are to be fabricated symmetrical sections with integral upper and lower brackets and are to be arranged with soft toes.

The frame face plate is to be curved (not knuckled) at the connection with the end brackets. The radius of curvature, 'r', is not to be less than :

$$r = \frac{0.4 b_f^2}{t_f} \ [mm]$$

where,

b_f and t_f are the width of the face plate and thickness of the brackets, respectively [mm]. The face plate, is to be sniped at the end.

In ships of length less than 190 [m], frames when made of ordinary mild steel, may be asymmetric and fitted with separate brackets. The face plate or flange of the bracket is to be sniped at both ends. Brackets are to be arranged with soft toes.

The web depth to thickness ratio of frames is not to exceed the following values:

$60\sqrt{k}$ for symmetric sections

$50\sqrt{k}$ for asymmetric sections

where,

k = material factor for the side frame.

In case of asymmetric sections, the breadth of the face plate or flange is not to exceed $10\sqrt{k}$ times its thickness.

2.5.5 In way of the foremost hold, side frames of asymmetric section are to be effectively supported by tripping brackets as shown in Fig.2.5.5.

2.5.6 The scantlings of hold side frames immediately adjacent to the collision bulkhead are to be suitably increased in order to prevent excessive deformation imposed on the shell plating. As an alternative, at least two supporting structures are to be fitted which align with forepeak stringers or flats as shown in Fig.2.5.6.

2.5.7 The dimensions of the lower and upper brackets are not to be smaller than those shown in Fig.2.5.7.

The section modulus of the frame and bracket or integral bracket and associated shell plating, at the locations marked 'Z_b' in Fig.2.5.7, is not to be less than twice the section modulus required for the frame in midspan area.

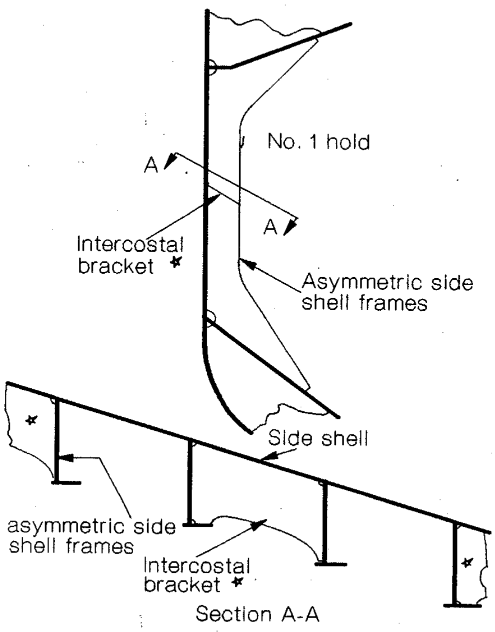


Fig.2.5.5 : Typical arrangement of inter-coastal brackets supporting asymmetric side shell frames in foremost hold

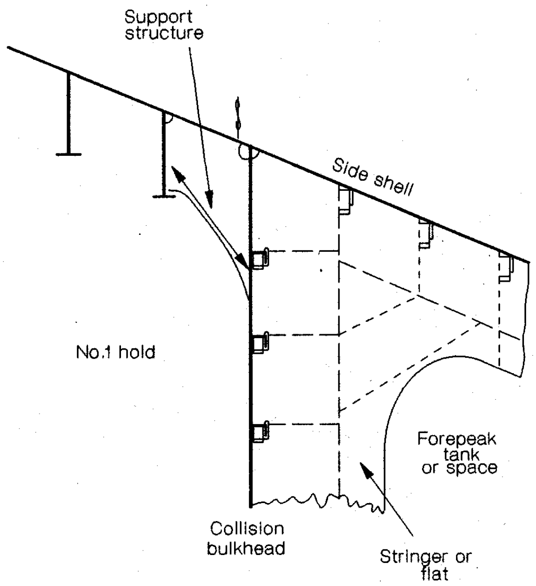


Fig.2.5.6 : Hold frame supporting structures aft of collision bulkhead

2.5.8 Double continuous welding is to be adopted for the connections of frames and brackets to side shell, hopper and upper wing tank plating and web to face plates. For this purpose, the weld factor is to be not less than:

0.44 in zone 'a' and
0.4 in zone 'b'

See Fig.2.5.8 for extent of zone 'a' and 'b'.

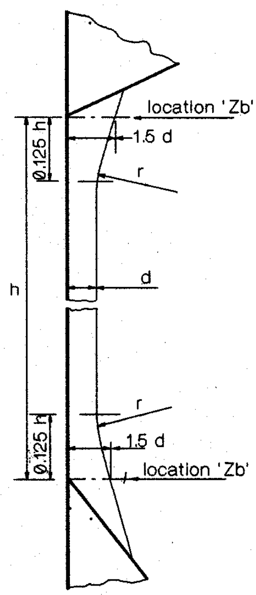


Fig.2.5.7 : Minimum dimensions of end brackets

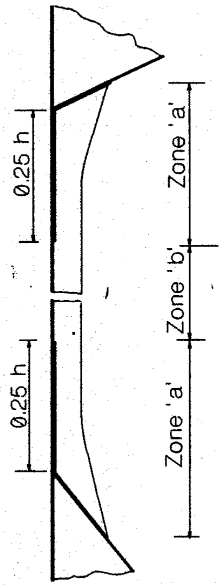


Fig.2.5.8 : Definition of zone 'a' & 'b' for welding

Where the hull form is such that an effective fillet weld can not be made, edge preparation of the web of frame and bracket may be required, in order to ensure the required efficiency of the weld connection.

2.5.9 At upper and lower end of frames, supporting brackets are to be arranged inside hopper and topside tanks, in line with the main frame brackets to provide adequate resistance to the rotation and displacement of the joint.

The thickness of the supporting brackets is generally to be the same as that of the main frame bracket.

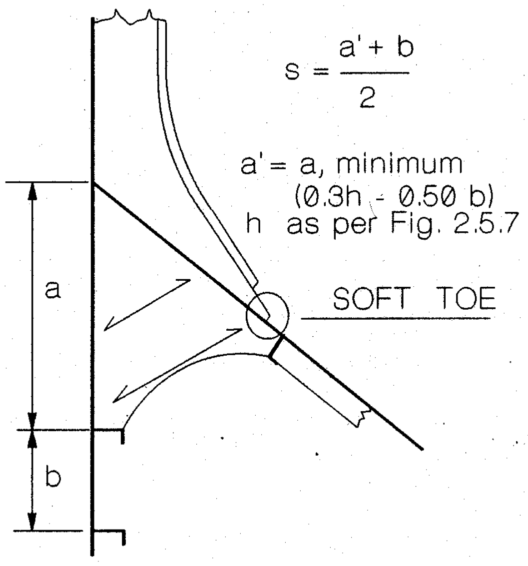


Fig.2.5.9 : Detail i.w.o. end brackets

Where the toe of the hold frame bracket is situated on or in close proximity of the first longitudinal on the hopper or topside tank sloping bulkhead from the side shell, the supporting brackets are to be extended to the next longitudinal. This extension is to be obtained by enlarging the supporting bracket or by fitting an intercostal flat bar stiffener of same depth as that of the longitudinal.

In all cases, the section moduli of the side longitudinals and sloping bulkhead longitudinals which are connected to the supporting brackets are to be determined using the spacing 's' as shown in Fig.2.5.9 and span taken between transverses.

2.6 Hopper side tank structure

2.6.1 Scantlings of sloped bulkhead plating and stiffening is to be as per Pt.3, Ch.10, based on the actual spacing of stiffeners; and dry bulk cargo loading given in Sec.1.3 or as for a deep tank, whichever is higher.

2.6.2 Transverses supporting longitudinals are to be arranged in line with double bottom floors.

2.7 Topside tank structure

2.7.1 The scantlings of sloped bulkhead plating and stiffening is to be as per Pt.3, Ch.10, Sec.5, based on actual spacing of stiffeners and loading corresponding to 1.3 or as for a deep tank, whichever is higher.

2.7.2 Where the sloping bulkhead stiffeners are fitted on the hold side of the bulkhead, suitable arrangement to prevent tripping are to be provided.

2.7.3 Transverses supporting longitudinals are generally to be spaced not more than 3.6 [m] apart. They are also to be arranged in line with hatch end beams.

2.8 Deck structure

2.8.1 The deck within the line of hatchway openings is preferably to be stiffened transversely or alternatively the arrangements are to be such as to provide adequate buckling strength to resist athwartships forces acting on ship's sides.

2.8.2 In case of large bulk carriers with narrow deck strips between hatchways and for vessels of class notation “Strengthened for heavy cargoes”, with empty hold notation, the cross deck scantlings will be specially considered. See Pt.3, Ch.9, Sec.2.

2.8.3 Where the difference between the thickness of plating inside and outside the line of hatchway openings exceeds 12 [mm], a transitional plate of thickness equivalent to the mean of the adjacent plate thicknesses is to be fitted.

2.9 Corrugated bulkheads - Construction

2.9.1 Where bulkheads are of corrugated construction, the angle of corrugation (i.e. of webs with the plane of bulkheads) is not to be less than 55, See Fig.2.9.1.

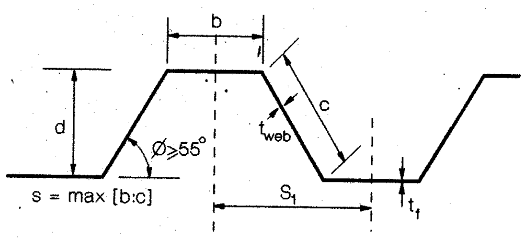


Fig.2.9.1 : Corrugated bulkhead

2.9.2 For ships of length 190 [m] and above, vertically corrugated transverse bulkheads are to be fitted with a lower stool and generally with an upper stool below deck.

For smaller ships, corrugated bulkheads may extend from inner bottom to deck. However, where a lower and/or upper stool is fitted in smaller ships, the requirements of 2.9.4 and/or 2.9.5 are to be complied with, as applicable.

2.9.3 Where no stool is fitted at bottom, supporting floors are to be provided in line with corrugation flanges. Corrugated bulkhead plating is to be connected to the inner bottom plating by full penetration welds. The plating of supporting floors is to be connected to the inner bottom by either full penetration or deep penetration welds as per Fig.2.9.3. The thickness and material specifi-cation of the supporting floors are to be atleast equal to those provided for the corrugation flanges. Additionally, the cut-outs for connections of the inner bottom longitudinals to double bottom floors are to be closed by collar plates. The supporting floors are to be connected to each other by means of shear plates.

Where no stool is fitted at deck, two transverse reinforced beams are to be fitted in line with the corrugation flanges.

2.9.4 The lower stool, where fitted, is generally to have a height equal to 3 times the depth of corrugation 'd'. The thickness and material specification of the stool top plate and the stool side plates within the depth equal to the corrugation flange width from the stool top should not to be less than the flange plate thickness and material specification required to meet the bulkhead stiffness requirement at the lower end of corrugation.

The distance of the edge of the stool top plate to the surface of the corrugation flange is to be in accordance with Fig.2.9.4.

The sloping stool side plating is to align with the corrugation flanges. Knuckles on stool side plating are not permitted.

The scantlings of the stool side plating and stiffeners are not to be less than those required for plane transverse bulkhead using corresponding ballast or cargo flooded pressure.

The stool side vertical stiffeners are to be bracketed at the top and bottom ends. The lower end brackets are to align with the inner bottom longitudinals.

The stool bottom is to be arranged in line with the double bottom floors and should have a width not less than 2.5 times the width of the top plate. These supporting floors are to have thickness and material properties not less than that of the lower strake of the bottom stool. Cut-outs for the connection of inner bottom longitudinals to these double bottom floors are to be closed by collar plates.

Diaphragms are to be fitted in line with longitudinal girders of the double bottom for effective support of the bulkhead. Scallops in the brackets and diaphragms in way of the top and bottom connections to the top plate and the double bottom floors/girders are to be avoided.

Where corrugations are cut at the bottom stool, corrugated bulkhead plating is to be connected to the stool top plate by full penetration welds. The stool side plating is to be connected to the stool top plate and the inner bottom plating by either full penetration or deep penetration welds as per Fig.2.9.3. The supporting floors are to be connected to the inner bottom by either full penetration or deep penetration welds as per Fig.2.9.3.

2.9.5 The upper stool, where fitted, is to have a height, measured at the hatch side girder, equal to 2 to 3 times the depth of corrugations. Rectangular stools are generally to have a height of 2 times the depth of corrugation. The upper stool is to be adequately supported by girders or deep brackets between the adjacent hatch-end beams.

The width of the stool bottom plate should generally be the same as that of the lower stool top plate. The stool top of non-rectangular stools are to have widths not less than 2 times the depth of corrugations. The thickness and material of the stool bottom plate is to be the same as that of the bulkhead plating below. The thickness of the lower portion of the stool side plating is to be not less than 80% of that required for upper part of the corrugated bulkhead plating, where same material is used.

The thickness of stool side plating and the section modulus of its stiffeners are to be not less than those required for plane transverse bulkheads and stiffening using corresponding ballast or cargo flooded pressure. The stool side stiffeners are to be attached to brackets at upper and lower end of the stool.

Diaphragms are to be fitted inside the stool in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate are to be avoided.

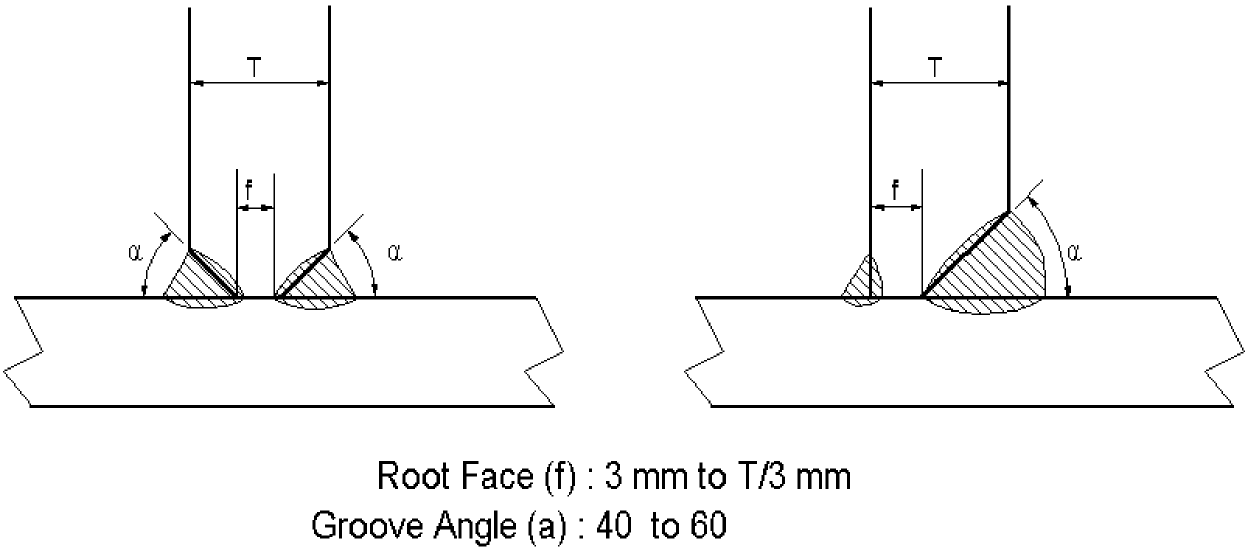


Fig. 2.9.3

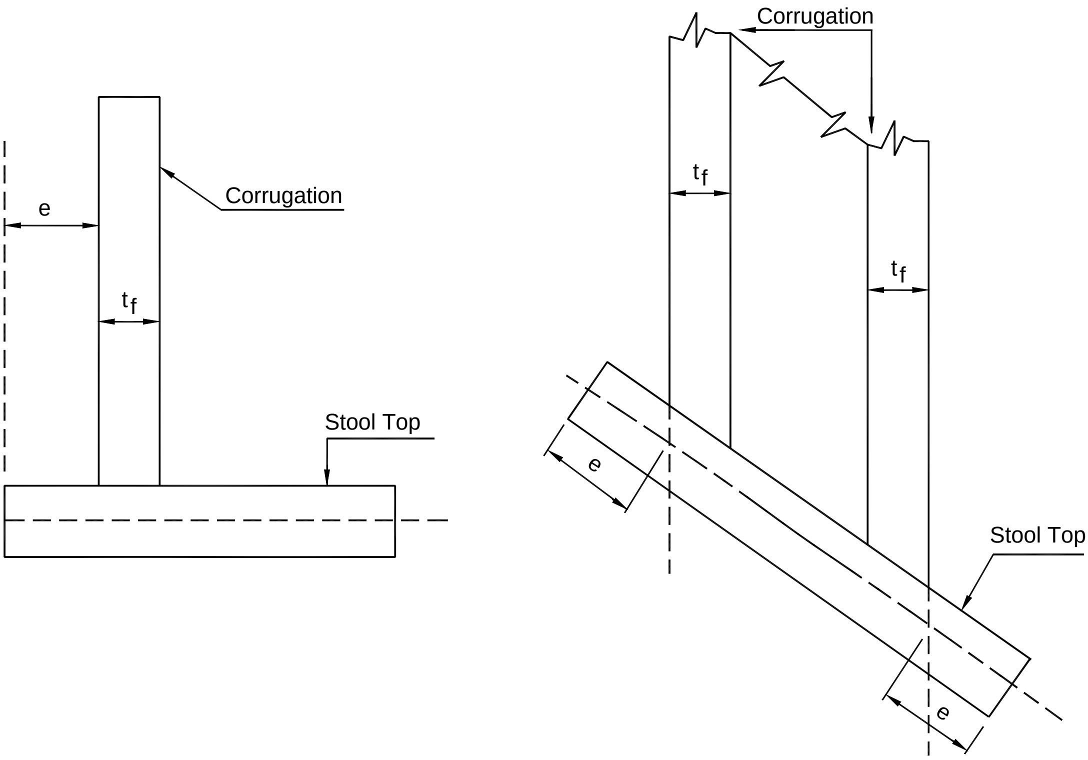


Fig.2.9.4 Permitted distance, e, from edge of stool top plate to surface of corrugation flange

2.10 Corrugated bulkheads - Strength

2.10.1 The scantlings of bulkheads are to be as per Pt.3, Ch.10, taking into account the dry bulk cargo loading given in 1.3.2 and, where applicable as per 2.10.3, the loading in cargo hold flooded condition as given in 1.3.3.

2.10.2 In way of ballast holds, the scantlings of bulkhead are not to be less than those required for a deep tank.

2.10.3 The following requirements apply to vertically corrugated transverse watertight bulkheads bounding those cargo holds which are required to be considered flooded for the hull girder longitudinal strength investigation in flooded conditions, as per 2.2.2.

2.10.4 The loads to be considered as acting on the bulkheads are those given by the combination of the cargo loads with those induced by the flooding of one hold adjacent to the bulkhead under examination. In any case, the pressure due to the flooding water alone is also to be considered.

The most severe combinations of cargo induced loads and flooding loads are to be used for the check of the scantlings of each bulkheads, depending on the loading conditions (homogeneous and non-homogeneous included in the loading manual).

Individual flooding of both loaded and empty holds is to be considered.

Non homogeneous part loading conditions associated with multiport loading and unloading operations for homogeneous loading conditions need not be considered.

2.10.5 In this context, homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold and corrected for differences in cargo densities, if any, does not exceed 1.20.

2.10.6 Holds carrying packed cargoes are to be considered as empty holds for this application.

Unless the ship is intended to carry, in non-homogeneous conditions, only iron ore or cargo having bulk density equal or greater than 1.78 [t/m^3], the maximum mass of cargo which may be carried in the hold shall also be considered to fill that hold upto the upper deck level at centreline.

2.10.7 At each point of the bulkhead structure, the resultant pressure p and the resultant force F, to be considered for the scantlings of the bulkhead, is given in Table 2.10.7:

Table 2.10.7 : Resultant pressures and forces

Loading condition	**p [N/mm^2]**	**F [kN]**
Homogeneous	p_{cF} - 0.8 p_c; Minimum p_f	$F_{c,f}$ - 0.8 F_c; Minimum F_f
Non-homogeneous	p_{cF}	$F_{c,f}$
Empty hold, flooded	p_f	F_f

where, pressures $p_{c,f}$, p_c, p_f and forces $F_{c,f}$, F_c and F_f are given in Table 1.3.3 and Fig.1.3.3.

2.10.8 The design bending moment M, [kN-m], for the bulkhead corrugations is given by:

$$M = \frac{F.l}{8}$$

where,

F = resultant force, [kN], as per 2.10.7.

l = span of the corrugation, [m], See Fig.2.10.8 (a), (b) and (c).

The shear force Q, [kN], at the lower end of the bulkhead corrugations is given by:

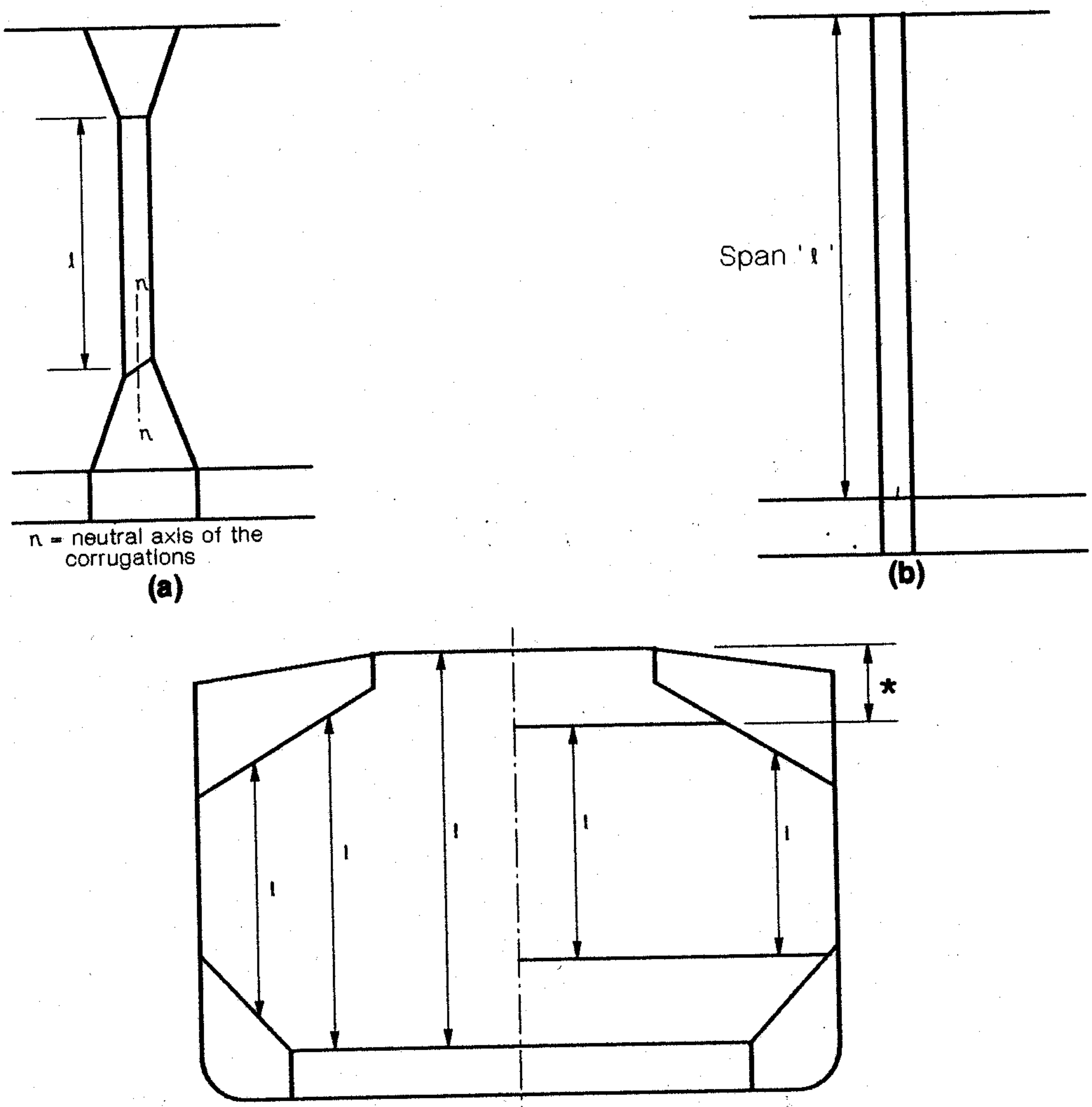
$$Q = 0.8.F$$

2.10.9 For the purpose of the calculations, the shedder plates can be considered effective provided they:

- are not knuckled;
- are attached to the corrugations and the top of the lower stool by one side penetration welds or equivalent;
- have with a minimum slope of 45 and their lower edge is in line with the stool side plating;
- have thicknesses not less than 75% of that of the corrugation flange;
- material properties are at least equal to that of the corrugation flanges.

2.10.10 For the purpose of the calculations, gusset plates can be considered effective provided they:

- act together with effective shedder plates
- have a height not less than half of the flange width
- are fitted in line with the stool side plating
- are generally welded to the top of the lower stool by full penetration welds, and to the corrugations and shedder plates by one side penetration welds or equivalent
- have thickness and material properties at least equal to those of the flanges.



* For the definition of l, the internal end of the upper stool is not to be taken more than a distance from the deck at the centre line equal to - 3 times the depth of corrugations, in general
- 2 times the depth of corrugations, for rectangular stool

Fig.2.10.8 : Definition of span of corrugation

2.10.11 The thickness of the lower part of corrugations considered in the application of 2.10.12 to 2.10.14 are to be maintained for a distance from the inner bottom (if no lower stool is fitted) or the top of the lower stool not less than 0.15*l*;

The thickness of the middle part of the corrugations considered in the application of 2.10.12, 2.10.13 and 2.10.15 are to be maintained to a distance from the deck (if no upper stool is fitted) or the bottom of the upper stool not greater than 0.3*l*;

where '*l*' is the span of the corrugation as defined in 2.10.8.
The section modulus of the corrugation in the remaining upper part of the bulkhead is not to be less than 75% of that required for the middle part, corrected for difference in yield stresses, if any.

2.10.12 The bending capacity of the corrugations is to comply with the following relationship:

$$\frac{M.10^3}{[0.5.Z_{le}.(\sigma_y)_{le} + Z_m(\sigma_y)_m]} \le 0.95$$

where,

M = bending moment, [kN-m], as per 2.10.8

Z_{le} = section modulus, [cm^3], at the lower end of corrugations, to be calculated according to 2.10.14; but not to be taken greater than Z'_{le}.

Z_m = section modulus, [cm^3], at the mid-span of corrugations, to be calculated according to 2.10.15, but not to be taken greater than 1.15 times Z_{le} as defined above.

$(\sigma_y)_{le}$, $(\sigma_y)_m$ = minimum upper yield stress of the material at the lower end of corrugations and at the midspan of corrugations respectively.

$$Z'_{le} = Z_g + 10^3 . \frac{Q.h_g - 0.5.h_g^2.s_1.p_g}{\sigma_y}$$

where,

Z_g = section modulus [cm^3], of the corrugations calculated, according to 2.10.15 in way of the upper end of shedder or gusset plates, as applicable

Q = shear force [kN] as per 2.10.8

h_g = height [m] of shedders or gusset plates, as applicable (See Fig.2.10.11 a, b, c, d & e)

s_1 = corrugation spacing [mm]. See Fig.2.9.1

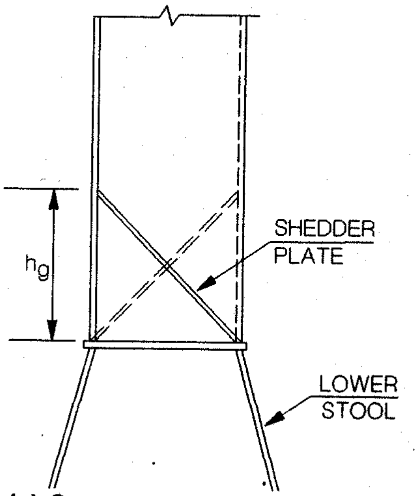
p_g = resultant pressure [N/mm^2] as per 2.10.7, calculated in way of the middle of the shedders or gusset plates, as applicable.

2.10.13 The net plate thickness to be used in the calculations of scantlings as per 2.10.14 to 2.10.17 is to be obtained by:

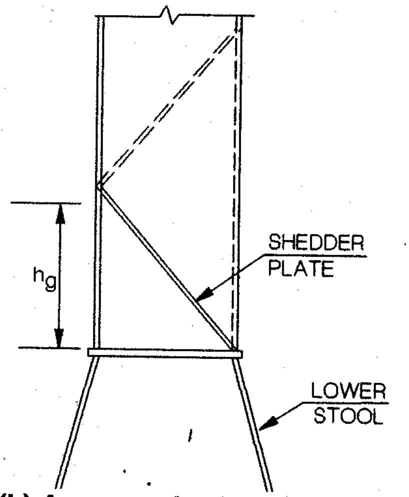
$$t_{net} = t - 3.5 \text{ [mm]}$$

where,

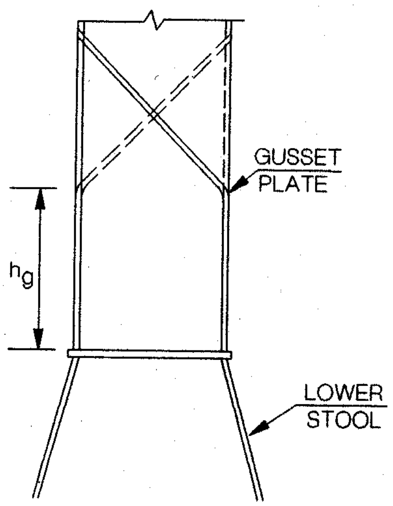
t is the actual thickness provided.



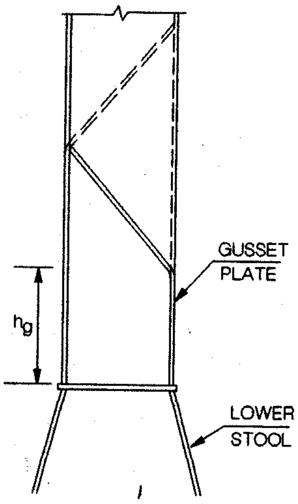
(a) Symmetric shedder plates



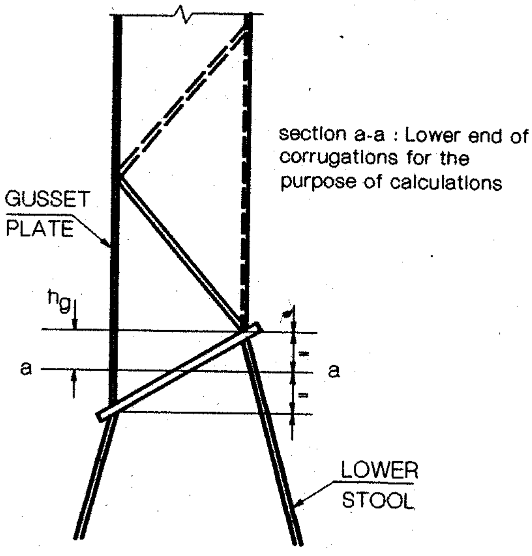
(b) Asymmetric shedder plates



(c) Symmetric gusset/shedder plates



(d) Asymmetric gusset/shedder plates



(e) Gusset/shedder plates with sloped stool top

Fig.2.10.11 : Arrangement of guesset/shedder plates

2.10.14 The section modulus of the lower end of corrugation is to be calculated using the net plate thicknesses and with the compression flange having an effective flange width, b_{ef} [m] not larger than:

$$b_{ef} = C_e \cdot b$$

where,

$$C_e = \frac{2.25}{\beta} - \frac{1.25}{\beta^2}; \text{ max. } 1.0$$

$$\beta = 10^3 \cdot \frac{b}{t_f} \cdot \sqrt{\sigma_y / E}$$

t_f = net flange thickness [mm].

b = width [m] of the corrugation flange. See Fig.2.9.1

σ_y = minimum upper yield stress [N/mm^2], of the material

E = modulus of elasticity of the material [N/mm^2].

If corrugation webs are not supported by local brackets below the stool top (or below the inner bottom) in the lower part; or above the stool bottom (or in way of the upper deck) in the upper part; the section modulus is to be calculated considering the corrugation webs 30% effective.

i) Where effective shedder plates, as per 2.10.9 are fitted, the section modulus of corrugations at the lower end may be calculated with the area of flange plates increased by (0.0025.b.$\sqrt{t_f \cdot t_{sh}}$ [cm^2]

where,

b = width [mm] of the corrugation flange

t_f = net flange thickness [mm]

t_{sh} = net shedder plate thickness [mm]; but not to be taken greater than t_f.

ii) Where effective gusset plates, as per 2.10.10 are fitted, the section modulus of corrugations at the lower end may be calculated with the area of flange plates increased by (7 . h_g . t_f) [cm^2]

where,

h_g = height of gusset plate [m]; but not to be taken greater than $\left(\frac{10}{7} \cdot s_{gu}\right)$.

See Fig.2.10.11c, d and e.

s_{gu} = width of the gusset plates [m]

t_f = net flange thickness [mm]

iii) Where corrugation webs are welded to a sloping stool top plate which has an angle not less than 45^o with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. In case effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in (ii) above. No credit can be given to shedder plates only. See Fig.2.10.11e.

For angles less than 45^o, the effectiveness of the web may be obtained by linear interpolation between 30% for 0^o and 100% for 45^o.

2.10.15 The section modulus of corrugations at cross sections other than the lower end is to be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, b_{ef}, as defined in 2.10.14.

2.10.16 Shear stresses τ are obtained by dividing the shear force Q by the shear area. When calculating the shear area, the net plate thicknesses are to be used. The shear area is to be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by (sin α), α being the angle between the web and the flange.

Calculated shear stress is to comply with the following:

$$\tau \leq 0.5\, \sigma_y$$

where,

σ_y = minimum upper yield stress of the material.

Shear buckling check is to be performed for the web plates at the corrugation ends, to ensure that the actual shear stress does not exceed the critical shear buckling stress, i.e.

$$\sigma_{cr} \geq \sigma_c$$

where,

σ_c = actual shear stress calculated for the web plate

σ_{cr} = the critical shear buckling stress as per Pt.3, Ch.3, Sec.6.1.4. The ideal elastic buckling stress in shear is to be computed as per Pt.3, Ch.3, Sec.6.2.2 with the value K_s = 6.34.

2.10.17 The bulkhead local net plate thickness t, [mm], is given by:

$$t = 0.483 \cdot s \cdot \sqrt{p / \sigma_y}$$

s = plate width, [mm], to be taken equal to the width of the corrugation flange or web, whichever is the greater. See Fig.2.9.1.

p = resultant pressure, [N/mm^2], as defined in 2.10.7, at the bottom of each strake of plating.

σ_y = minimum upper yield stress [N/mm^2], of the material.

In all cases, the net thickness of the lowest strake is to be determined using the resultant pressure at the top of the lower stool, or at the inner bottom, if no lower stool is fitted or at the top of shedders, if shedder or gusset/shedder plates are fitted.

For built-up corrugation bulkheads, when the thicknesses of the flange and web are different, the net thickness requirements are to be calculated as per the above formula using the respective width of web or flange. In addition the net thickness of the wider plating is to be not less than:

$$t = \sqrt{0.462 \; \frac{s^2 p}{\sigma_y} - t_a^2} \quad \text{[mm]}$$

where,

t_a = net thickness of the adjacent plating [mm].

2.10.18 The design of local details is to be adequate for the purpose of transferring the corrugated bulkhead forces and moments to the boundary structures, in particular, the double bottom and cross-deck structures.

The thickness and stiffening of effective gusset and shedder plates, are to be based on loads as per 2.10.4, see also 2.10.5 and 2.10.6.

2.11 Protective coatings for cargo hold spaces

2.11.1 All internal and external surfaces of hatch coamings and hatch covers and all internal surfaces of the cargo holds, excluding the flat tank top areas and the hopper tank sloping plating extending upwards upto approximately 300 [mm] below the side shell frame and brackets, are to have an efficient protective coating (epoxy or equivalent) applied in accordance with the manufacturers recommendations.

2.11.2 In the selection of coating, due consideration is to be given by the Owner to intended cargo conditions expected in service.

2.12 Damage stability requirements

2.12.1 Bulk carriers of single side skin construction as defined in 1.1.2.2 and of length 150 [m] and above designed to carry solid bulk cargoes having a density of 1.0 tonnes per cubic metre and above, the keels of which are laid or are at a similar stage of construction on or after 1 July, 1999 shall, when loaded to the summer load line, be able to withstand flooding of any one cargo hold in all loading conditions and remain afloat in a satisfactory condition of equilibrium, as specified in 2.12.4.

2.12.2 Bulk carriers of single side skin construction as defined in 1.1.4, in the foremost cargo hold and of length 150 [m] and above carrying solid bulk cargoes having a density of 1.78 tonnes per cubic metre and above, the keels of which are laid or are at a similar stage of construction before 1 July 1999 shall, when loaded to the summer loadline, be able to withstand flooding of the foremost cargo hold in all loading conditions and remain afloat in a satisfactory condition of equilibrium, as specified in 2.12.4. This requirement shall be complied with in accordance with the schedule given in Pt.1, Ch.2, Sec.2.4.12 for compliance with IMO standards for scantlings of transverse bulkhead between the two foremost cargo holds and allowable hold loading for the foremost cargo hold.

2.12.3 Bulk carriers of double side skin construction as defined in 1.1.2.3 and of length 150 [m] and above in which any part of the longitudinal bulkhead is located within B/5 or 11.5 [m], whichever is less, inboard from the ship's side at right angle to the centerline at the assigned summer load line, designed to carry solid bulk cargoes having a density of 1000 [kg/m^3] and above, shall be able to withstand when loaded to the summer load line, flooding of any one cargo hold in all loading conditions and remain afloat in a satisfactory condition of equilibrium as specified in 2.12.4.

2.12.4 Subject to the provisions of 2.12.7 below, the condition of equilibrium after flooding shall satisfy the condition of equilibrium laid down in the annex to resolution A.320(IX) - Regulation equivalent to Regulation 27 of the International Convention on Load Lines, 1966, as amended by Resolution A.514(13). The assumed flooding need only take into account flooding of the cargo hold space. The permeability of a loaded hold shall be assumed as 0.9 and the permeability of an empty hold shall be assumed as 0.95, unless a permeability relevant to a particular cargo is assumed for the volume of a flooded hold occupied by cargo and a permeability of 0.95 is assumed for the remaining empty volume of the hold.

2.12.5 Bulk carriers contracted before 1 July, 1998 which have been assigned a reduced freeboard in compliance with regulation 27(7) of the International Convention on Load Lines, 1966, may be considered as complying with the requirements of 2.12.2.

2.12.6 Bulk carriers which have been assigned a reduced freeboard in compliance with the provisions of paragraph (8) of the regulation equivalent to regulation 27 of the International Convention on Load Lines, 1966, adopted by resolution A.320(IX), as amended by resolution A.514(13), may be considered as complying with the requirements of 2.12.1, 2.12.2 or 2.12.3, as appropriate.

2.12.7 On bulk carriers which have been assigned reduced freeboard in compliance with the provisions of regulation 27(8) set out in Annex B of the Protocol of 1988 relating to the International Convention on Load Lines, 1966, the condition of equilibrium after flooding shall satisfy the relevant provisions of that Protocol.

2.13 Hold, ballast and dry space water level detectors

2.13.1 All bulk carriers are to be fitted with water level detectors as indicated in a), b) and c) below:

a) In each cargo hold, giving audible and visual alarms, one when the water level above the inner bottom in any hold reaches a height of 0.5 [m] and another at a height not less than 15% of the depth of the cargo hold but not more than 2 [m].

   If bulk carriers are exempted by the Administration from the compliance of SOLAS Chapter XII Reg.4.2 and 6 according to the provisions of SOLAS Chapter XII Reg.9, then only one alarm at a water level of not less than 15% of the depth of the cargo hold but not more than 2 [m] needs to be provided.

   The water level detectors are to be fitted in the aft end of the cargo holds.

   For cargo holds which are used for water ballast, an alarm overriding device is to be installed.

   The visual alarms are to clearly discriminate between the two different water levels detected in each hold.

b) In any ballast tank forward of the collision bulkhead giving an audible and visual alarm when the liquid in the tank reaches a level not exceeding 10% of the tank capacity. An alarm overriding device is to be installed for activation when the tank is in use; and

c) In any dry or void space other than a chain cable locker, any part of which extends forward of the foremost cargo hold, giving an audible and visual alarm at a water level of 0.1 [m] above the deck. Such alarms need not be provided in enclosed spaces if the volume of the space does not exceed 0.1% of the ship's maximum displacement volume.

The audible and visual alarms described in a), b) and c) above are to be located on the navigation bridge.

Note : The water level detectors are to be of approved type. For further details regarding performance tests, sensor locations, installation and other testing requirements refer classification notes: "Type approval, installation and testing of water level detectors on bulk carriers and Single Hold Cargo Ships other than Bulk Carriers".

2.14 De-watering of forward spaces

2.14.1 On bulk carriers, the means for draining and pumping ballast tanks forward of the collision bulkhead and bilges of dry spaces any part of which extends forward of the foremost cargo hold, is to be capable of being brought into operation from a readily accessible enclosed space, the location of which is accessible from the navigation bridge or propulsion machinery control position without traversing exposed freeboard or superstructure decks.

In this context, an enclosed space accessible via an under deck passage, a pipe trunk or other similar means of access is not considered as a "readily accessible enclosed space".

2.14.2 Where pipes serving tanks or bilges pierce the collision bulkhead, valve operation by means of remotely operated actuators may be accepted, as an alternative to the valve control specified in Pt.4, Ch.3, 2.4.4 and IR2.4.4, provided that the location of such valve controls complies with 2.14.1.

2.14.3 Where the piping arrangements for dewatering closed dry spaces are connected to the piping arrangements for the drainage of water ballast tanks, two non-return valves located in accessible positions, are to be provided to prevent the ingress of water into dry spaces from those intended for the carriage of water ballast. One of these non-return valves is to be fitted with shut-off isolation arrangement capable of being controlled from the same readily accessible enclosed space specified in 2.14.1.

2.14.4 The failure of either control system power or actuator power is not to alter the valve position.

2.14.5 Positive indication is to be provided at the remote control station to show that the valve is fully open or closed.

2.14.6 The dewatering arrangements are to be such that any accumulated water can be drained directly by a pump or educator.

2.14.7 When the dewatering arrangements are in operation, other systems essential for the safety of the ship including fire-fighting and bilge systems are to remain available and ready for immediate use. The systems for normal operation of electric power supplies, propulsion and steering should not be affected by the operation of the dewatering systems. It must also be possible to immediately start fire pumps and have a ready available supply of fire-fighting water and to be able to configure and use bilge system for any compartment when the dewatering system is in operation.

2.14.8 Bilge wells are to be provided with gratings or strainers that will prevent blockage of the dewatering system with debris.

2.14.9 The enclosures of electrical equipment for the dewatering system installed in any of the forward dry spaces are to provide protection to IPX8 standard as defined in IEC Publication 60529 for a water head equal to the height of the space in which the electrical equipment is installed for a time duration of at least 24 hours.

2.14.10 The requirements given in 2.14.1 to 2.14.9 are not applicable to the enclosed spaces whose volume does not exceed 0.1% of the ship's maximum displacement volume and to the chain locker.

2.15 Dewatering capacity

2.15.1 The dewatering system for ballast tanks located forward of the collision bulkhead and for bilges of dry spaces any part of which extends forward of the foremost cargo hold is to be designed to remove water from the forward spaces at a rate of not less than 320A [m^3/h], where A is the cross-sectional area in [m^2] of the largest air pipe or ventilator pipe connected from the exposed deck to a closed forward space that is required to be dewatered by these arrangements.

Section 3

Ore Carriers

3.1 Hull arrangement

3.1.1 The vessel is to have two effective longitudinal bulkheads and a double bottom in way of the cargo holds. It is assumed that only spaces between the longitudinal bulkheads are used as cargo holds. A double bottom is to be fitted in way of the cargo holds.

3.1.2 The bottom and deck outside the line of openings are to be longitudinally framed. The side shell and longitudinal bulkheads also, in general, are to be longitudinally framed. Inside line of openings, the deck is generally to be transversely stiffened.

3.2 Longitudinal strength

3.2.1 The longitudinal strength requirements as detailed in Pt.3, Ch.5 are to be complied with.

3.3 Bottom structure

3.3.1 The scantlings and arrangements are in general, to be as per Pt.3 Ch.7 except as given below.

3.3.2 Spacing of floors in the double bottom in centre hold is not to exceed 2.5 [m] or 0.01L whichever is greater. Additional side girders are to be provided below the centre hold so that the spacing of longitudinal girders generally does not exceed 3.6 [m].

3.3.3 The spacing of bottom transverses in the wing tanks is not to exceed the greater of 0.02L or 3.6 [m].

3.3.4 The thickness of inner bottom plating in cargo holds is to be based on the design loads given in Sec.1.3, however not to be less than:

$t = (9 + 0.012s)\sqrt{k} + t_c$ [mm].

3.4 Wing tank structure

3.4.1 In wing tanks, primary bottom structure is to be so arranged as to maintain structural continuity of the hold double bottom structure in the transverse direction.

3.4.2 The inner bottom plating is to be extended into the wing tank in the form of a horizontal gusset plate. The gusset plates are to be of sufficient width to provide effective scarfing of the inner bottom into the wing tank structure.

3.4.3 At locations where bottom transverses are not provided in line with plate floors in the hold double bottom, substantial brackets are to be arranged in line with such plate floors. These brackets are to extend transversely over at least three longitudinal spaces and vertically well above the inner bottom level.

3.4.4 In the wing tanks, bulkheads are to be arranged in line with the centre hold bulkheads so that continuity of transverse strength is maintained.

3.4.5 All watertight and non-watertight bulkheads in wing tanks are to be suitably reinforced in way of double bottom scarfing arrangements and also at the ends of centre hold deck transverses. Openings in wing tank bulkheads are to be kept clear of these areas.

3.5 Deck structure

3.5.1 The arrangement and scantlings of deck plating inside line of ore hatchways are to be in accordance with the requirements for bulk carriers given in Sec.2.8.

3.5.2 When the hatch coamings are situated inboard of the longitudinal bulkhead, the portion of the deck between the two is to be suitably supported by longitudinals.

3.6 Additional requirements for ore carriers with narrow wing tanks

3.6.1 For ore carriers of 150 [m] in length and above, in which any part of longitudinal bulkhead is located within B/5 or 11.5 [m], whichever less, inboard from ship side at right angle to the centerline at the assigned summer load line, are to comply with the following additional requirements given in 3.6.2 to 3.6.6.

3.6.2 The longitudinal strength in the hold flooded condition is to comply with the requirements given in 2.2.3 to 2.2.7.

3.6.3 The thickness of the inner bottom plating and the section modulus of inner bottom longitudinals are to comply with the requirements given in 2.3.3 and 2.3.4 respectively.

3.6.4 The shear capacity of the double bottom is to comply with the requirements of 2.4.3 to 2.4.5.

3.6.5 The thickness longitudinal bulkhead plating and stiffeners are to be in accordance with Pt.3, Ch.10 using the design loads in hold flooded conditions given in Pt.3, Ch.10 section 5 using f_s based on SWBM and WBM in hold flooded conditions.

3.6.6 The construction and strength of transverse corrugated bulkheads is to be as per 2.9 and 2.10 respectively.

Section 4

Direct Strength Calculations

4.1 General

4.1.1 Direct strength calculations are required in cases where simplified formulations are not able to take into account special stress distributions, boundary conditions or structural arrangements with sufficient accuracy.

4.1.2 The scantlings of the double bottom and transverse bulkhead structures in cargo region and top wing tank/deck structures over long holds, obtained from simplified formulae may have to be increased based on the results of the direct strength calculations.

4.1.3 The computer programs used are to take into account the effects of bending, shear, axial and torsional deformations.

4.1.4 For deep girders, bulkhead panels, bracket zones etc. FEM or equivalent methods are to be applied. For systems consisting of slender girders, calculations may be based on beam theory.

In case of corrugated bulkheads, the dimension of the elements used to model the corrugations may be the width of the flange, the first row of elements from the top of the stool is to have an aspect ratio equal to 1 and for the other elements, the aspect ratio is not to exceed 3;

4.1.5 The calculations are to reflect the structural response of 2 or 3-dimensional structure considered, with due attention to the boundary conditions. The minimum longitudinal extent of the model is to be half the hold length on either side of the transverse bulkhead and transversely, the model is to extend over a minimum of half the ship breadth.

4.1.6 The calculations are to be carried out using net thicknesses obtained after deduction of applicable corrosion additions specified in 2.4.3 and 2.10.13 and those in Pt.3, Ch.3.

4.2 Load cases and design loads

4.2.1 The calculations are to be carried out for realistic intact and flooded conditions which cause most severe loading on double bottom, bulkhead and top side structures.

The ship and individual hold loading conditions specified in 1.2 are also to be considered for the evaluation of strength.

4.2.2 The following cases are generally to be included:

a) Ballast in ballast hold with adjacent holds empty, at minimum ballast draught T_b - with respect to double bottom, transverse bulkhead and top wing tank/ship side strength.

b) Ballast in top wing tank - with respect to top wing tank strength in the upright and heeled conditions, where angle of heel is to be taken equal to half the angle of roll as given in Pt.3, Ch.4.

c) Heavy ore cargo in hold, hold considered flooded with adjacent hold empty - with respect to double bottom of the loaded and adjacent empty holds and transverse bulkhead in between.

d) Maximum cargo in the hold filled upto the top of hatch coaming, hold considered flooded - with respect of transverse bulkhead structure.

e) Specified cargo on deck and external sea pressure on deck (in particular forward holds) with respect to deck and top wing tank structure.

4.2.3 Normally, harbour conditions need not be considered provided the minimum draught in harbour with cargo hold filled, is not less than two thirds of the draught in the associated approved seagoing condition.

4.2.4 The internal pressures on transverse bulkheads and inner bottom are to be taken as per Sec.1.4. The external sea pressures are to be taken as per Pt.3.Ch.4 based on the draught at midhold.

4.3 Allowable stresses

4.3.1 The values of allowable stresses given below are subject to satisfactory buckling strength as per Pt.3, Ch.3 and Pt.3, Ch.10 for bulkhead corrugations.

4.3.2 In the double bottom structures the combined longitudinal stress 'σ_{LC}', is not to exceed 230/k [N/mm^2].

$$\sigma_{LC} = \sigma_L + \sigma_{DB} + \sigma_g \ \ [N/mm^2]$$

σ_L = hull girder bending stress based on total bending moment (M_s + M_w) as given in Pt.3, Ch.5, Sec.2.2 (hogging and sagging) as relevant.

σ_{DB} = stress in the double bottom structure at base line inner bottom level or at flanges of the longitudinals as relevant.

σ_g = local bending stress due to lateral pressure, in the flanges of bottom or inner bottom longitudinal under consideration [N/mm^2].

4.3.3 In case of transverse bulkhead girders or corrugations, the following stress values are not to be exceeded in intact conditions:

For bulkheads of ballast holds:	
Bending or axial stress	σ = 160/k [N/mm^2]
Shear stress	τ = 100/k [N/mm^2]
Equivalent stress	$\sigma_e = \sqrt{(\sigma^2 + 3\tau^2)}$ = 180/k [N/mm^2]

For bulkheads of cargo holds:	
Bending or axial stress	σ = 210/k [N/mm^2]
Shear stress	τ = 115/k [N/mm^2]
Equivalent stress	σ_e = 225/k [N/mm^2]

Section 5

Hatch Cover and Hatch Coamings of Cargo Holds

5.1 Application and definitions

These requirements apply to all bulk carriers, ore carriers and combination carriers and are for all cargo hatch covers and hatch forward and side coamings on exposed decks in position 1, as defined in Pt.3, Ch.12, Sec.1.2.

The strength requirements are applicable to hatch covers and hatch coamings of stiffened plate construction. The secondary stiffeners and primary supporting members of the hatch covers are to be continuous over the breadth and length of the hatch covers, as far as practical. When this is impractical, sniped end connections are not to be used and appropriate arrangements are to be adopted to provide sufficient load carrying capacity.

The spacing of primary supporting members parallel to the direction of secondary stiffeners is not to exceed 1/3 of the span of primary supporting members.

The secondary stiffeners of the hatch coamings are to be continuous over the breadth and length of the hatch coamings.

The net minimum scantlings of hatch covers are to fulfill the strength criteria given in:

- 5.3.3, for plating,
- 5.3.4, for secondary stiffeners,
- 5.3.5 for primary supporting members;

the critical buckling stress check in 5.3.3.2 and the rigidity criteria given in 5.3.6, adopting the load model given in 5.2.

The net minimum scantlings of hatch coamings are to fulfill the strength criteria given in:

- 5.4.2, for plating,
- 5.4.3, for secondary stiffeners,
- 5.4.4, for coaming stays,

adopting the load model given in 5.4.1.

The net thicknesses, $t_{net,}$ are the member thicknesses necessary to obtain the minimum net scantlings required by 5.3 and 5.4.

The required gross thicknesses are obtained by adding the corrosion additions, t_c, given in 5.6, to t_{net}.

Material for the hatch covers and coamings is to be steel according to the requirements for ship’s hull.

5.2 Hatch cover load model

The pressure p, [N/mm^2], on the hatch covers panels is given by:

i) For ships of 100 [m] in length and above

$$p = \left\{34.3 + \frac{p_{FP} - 34.3}{0.25}\left(0.25 - \frac{x}{L_L}\right)\right\}.10^{-3} \geq 34.3\,x10^{-3}$$

for hatchways located at the freeboard deck

where:

p_{FP} = pressure at the forward perpendicular
= [49.1 + (L-100)a] . 10^{-3}

a = 0.0726 for type B freeboard ships
0.356 for ships with reduced freeboard

L_L = Freeboard length, [m], as defined in Pt.3, Ch.1, Sec.2 to be taken not greater than 340 [m]

x = distance, [m], of the mid length of the hatch cover under examination from the forward end of L

Where a position 1 hatchway is located at least one superstructure standard height higher than the freeboard deck, the pressure “p” may be 34.3 x 10^{-3} [N/mm^2].

For ships less than 100 [m] in length

$$p = \left\{15.8 + \frac{L_L}{3}\left(1 - \frac{5}{3}.\frac{x}{L_L}\right) - 3.6\frac{x}{L_L}\right\}.10^{-3}$$

$$\geq \left(0.195L_L + 14.9\right).10^{-3}$$

ii) for hatchways located at the freeboard deck

Where two or more panels are connected by hinges, each individual panel is to be considered separately.

5.3 Hatch cover strength criteria

5.3.1 Allowable stress checks

The normal and shear stresses σ and τ in the hatch cover structures are not to exceed the allowable values, σ_a and τ_a, [N/mm^2], given by:

$\sigma_a = 0.8\ \sigma_F$

$\tau_a = 0.46\ \sigma_F$

σ_F being the minimum upper yield stress, [N/mm^2], of the material.

The stresses in hatch covers that are designed as a grillage of longitudinal and transverse primary supporting members are to be determined by a grillage or a FE analysis.

When a beam or a grillage analysis is used, the secondary stiffeners are not to be included in the attached flange area of the primary members.

When calculating the stresses σ and τ, the net scantlings are to be used.

5.3.2 Effective cross-sectional area of panel flanges for primary supporting members

The effective flange area A_f, [cm^2], of the attached plating, to be considered for the yielding and buckling checks of primary supporting members, when calculated by means of a beam or grillage model, is obtained as the sum of the effective flange areas of each side of the girder web as appropriate:

$$A_F = \sum_{nf}(10b_{ef}\,t)$$

where:

nf = 2 if attached plate flange extends on both sides of girder web

= 1 if attached plate flange extends on one side of girder web only

t = net thickness of considered attached plate, [mm]

b_{ef} = effective breadth, [m] of attached plate flange on each side of girder web

= b_p, but not to be taken greater than 0.165ℓ

b_p = half distance, [m], between the considered primary supporting member and the adjacent one

ℓ = span, [m], of primary supporting members

5.3.3 Local net plate thickness

5.3.3.1 The local net plate thickness t, [mm], of the hatch cover top plating is not to be less than:

$$t = F_p 15.8s\sqrt{\frac{p.10^{-3}}{0.95\sigma_F}}$$

but to be not less than 1% of the spacing of the stiffener or 6 [mm] if that be greater.

where:

F_p = factor for combined membrane and bending response
= 1.50 in general
= 1.90 σ/σ_a, for $\sigma/\sigma_a \geq 0.8$, for the attached plate flange of primary supporting members

s = stiffener spacing, [m]

p = pressure, [kN/m^2], as defined in 5.2

σ = as defined in 5.3.5

σ_a = as defined in 5.3.1.

5.3.3.2 The compressive stress σ_c in hatch cover plate panels induced by the bending of primary supporting members is not to exceed 0.8 times the critical compressive buckling stress σ_{cr}.

The critical compressive buckling stress and the ideal elastic buckling stress are to be determined as given in 6.1.2 and 6.2.1 respectively of Chapter 3.

The 'K' value in 6.2.1 of Chapter 3 is to be taken as follows:

a) Where the primary supporting member is parallel to the direction of secondary stiffeners, the 'K' value corresponding to plating with stiffeners in the direction of compressive stress is to be considered.

b) Where the primary supporting member is perpendicular to the direction of secondary stiffeners, 'K' value corresponding to plating with stiffeners in the direction perpendicular to the compressive stress is to be considered.

5.3.3.3 Biaxial compressive stress in hatch cover panels, when calculated by means of FEM shell element model, will be specially considered.

5.3.4 Net scantlings of secondary stiffeners

5.3.4.1 The required minimum section modulus, Z, [cm^3], of secondary stiffeners of the hatch cover top plate, based on stiffener net member thickness, are given by:

$$Z = \frac{1000\,\ell^2 sp}{12\sigma_a}.10^3$$

where:

ℓ = secondary stiffener span, [m], to be taken as the spacing, [m], of primary supporting members or the distance between a primary supporting member and the edge support, as applicable. When brackets are fitted at both ends of all secondary stiffener spans, the secondary stiffener span may be reduced by an amount equal to 2/3 of the minimum brackets arm length, but not greater than 10% of the gross span, for each bracket.

s = secondary stiffener spacing, [m]

p = pressure, [N/mm^2], as defined in 5.2

σ_a = as defined in 5.3.1.

The net section modulus of the secondary stiffeners is to be determined based on an attached plate width assumed equal to the stiffener spacing.

5.3.4.2 Stiffeners are to be connected to supporting primary members or cover edges by double continuous fillet weld of area not less than:

$$\frac{5\,(l_1 + l_2)\,sp}{2\,\tau_a}\ [\mathrm{cm}^2]$$

where l_1 and l_2 are the stiffener spans [m] on each side of the support.

τ_a = allowable shear stress as per 5.3.1.

Connection of the web plate of stiffeners or primary members to the attached plating and flanges is to be by means of double continuous fillet welds within 150 [mm] from ends and also in way of other areas of high shear stresses. The throat thickness in these areas is not to be less than 0.4 web plate thickness.

For covers above cargo and ballast tanks, chain or staggered fillet welds on the tank side are not acceptable.

5.3.4.3 The compressive stress σ_c in the top flange of secondary stiffeners, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, is not to exceed 0.8 times the critical buckling stress σ_{cr}. for the stiffener.

5.3.4.4 The critical buckling stress σ_{cr} for the stiffener is to be determined as given in 6.1.2 of Ch.3 using the ideal elastic buckling stress σ_E calculated as per the following:

- σ_E for lateral buckling mode as given in 6.2.3 of Ch.3, or
- σ_E for the torsional buckling mode as given in 6.2.4 of Ch.3.

whichever is the lower.

5.3.4.5 For flat bar secondary stiffeners and stiffeners used solely to prevent buckling, the ratio h_w/t_w is to be not greater than :

$$15\left(\frac{235}{\sigma_F}\right)^{0.5}$$

where;

h_w, t_w are the height and net thickness of the stiffener respectively

σ_F = minimum upper yield stress [N/mm^2] of the material.

5.3.5 Net scantlings of primary supporting members

5.3.5.1 The section modulus and web thickness of primary supporting members, based on member net thickness, are to be such that the normal stress σ in both flanges and the shear stress τ, in the web, do not exceed the allowable values σ_a and τ_a, respectively, defined in 5.3.1.

The breadth of the primary supporting member flange is to be not less than 40% of their depth for laterally unsupported spans greater than 3.0 [m]. Tripping brackets attached to the flange may be considered as a lateral support for primary supporting members.

The flange outstand is not to exceed 15 times the flange thickness.

5.3.6 Deflection limit and connections between hatch cover panels

Load bearing connections between the hatch cover panels are to be fitted with the purpose of restricting the relative vertical displacements.

The vertical deflection of primary supporting members is to be not more than 0.0056ℓ, where ℓ is the greatest span of primary supporting members.

5.4 Hatch coamings and local details

5.4.1 Load model

The pressure p_{coam}, [N/mm^2], on the No. 1 forward transverse hatch coaming is given by:

p_{coam} = 220 . 10^{-3}, [N/mm^2], when a forecastle is fitted in accordance with 1.4

= 290 . 10^{-3}, [N/mm^2], in the other cases

The pressure p_{coam}, [N/mm^2], on the other coamings is given by:

p_{coam} = 220 . 10^{-3}, [N/mm^2].

5.4.2 Local net plate thickness

The local net plate thickness t, [mm], of the hatch coaming plating is given by:

$$t = 14.9s\sqrt{\frac{p_{coam}.10^3}{\sigma_{a,coam}}S_{coam}}$$

where:

s = secondary stiffener spacing, [m]

p_{coam} = pressure, [N/mm^2], as defined in 5.4.1

S_{coam} = safety factor to be taken equal to 1.15

$\sigma_{a,coam} = 0.95\,\sigma_F$

The local net plate thickness is to be not less than 9.5 [mm].

5.4.3 Net scantlings of longitudinal and transverse secondary stiffeners

The required section modulus Z, [cm^3], of the longitudinal or transverse secondary stiffeners of the hatch coamings, based on net member thickness, is given by:

$$Z = \frac{1000S_{coam}\ell^2 sp_{coam}.10^3}{mc_p\sigma_{a.coam}}$$

where:

m = 16 in general

= 12 for the end spans of stiffeners sniped at the coaming corners

S_{coam} = safety factor to be taken equal to 1.15

ℓ = span, [m], of secondary stiffeners

s = spacing, [m], of secondary stiffeners

p_{coam} = pressure [N/mm^2] as defined in 5.4.1

c_p = ratio of the plastic section modulus to the elastic section modulus of the secondary stiffeners with an attached plate breadth, [mm], equal to 40 t, where t is the plate net thickness

= 1.16 in the absence of more precise evaluation

$\sigma_{a,coam}$ = 0.95 σ_F.

5.4.4 Net scantlings of coaming stays

The required minimum section modulus, Z, [cm^3], and web thickness, t_w, [mm] of coamings stays designed as beams with flange connected to the deck or sniped and fitted with a bracket (see Figures a) and b)) at their connection with the deck, based on member net thickness, are given by:

$$Z = \frac{1000 H_C^2 s p_{coam}}{2\sigma_{a.coam}} .10^3$$

$$t_w = \frac{1000 H_C s p_{coam}}{h \tau_{a.coam}} .10^3$$

H_C = stay height, [m]

s = stay spacing, [m]

h = stay depth, [mm], at the condition with the deck

p_{coam} = pressure, [N/mm^2], as defined in 5.4.1

$\sigma_{a,coam}$ = 0.95 σ_F

$\tau_{a,coam}$ = 0.5 σ_F

For calculating the section modulus of coaming stays, their face plate area is to be taken into account only when it is welded with full penetration welds to the deck plating and adequate underdeck structure is fitted to support the stresses transmitted by it.

For other designs of coaming stays, such as, for examples, those shown in Figures c) and d), the stress levels in 5.3.1 apply and are to be checked at the highest stressed locations.

5.4.5 Local details

The design of local details is to be suitable for the purpose of transferring the pressures on the hatch covers to the hatch coamings and, through them, to the deck structures below. Hatch coamings and supporting structures are to be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.

Underdeck structures are to be checked against the load transmitted by the stays, adopting the same allowable stresses specified in 5.4.4.

Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the rule requirements.

Double continuous welding is to be adopted for the connections of stay webs with deck plating and the weld throat is to be not less than 0.44 t_W, where t_W is the gross thickness of the stay web.

Toes of stay webs are to be connected to the deck plating with deep penetration double bevel welds extending over a distance not less than 15% of the stay width.

5.5 Closing arrangements

5.5.1 Securing devices

The strength of securing devices is to comply with the following requirements:

Panel hatch covers are to be secured by appropriate devices (bolts, wedges or similar) suitably spaced alongside the coamings and between cover elements.

Arrangement and spacing are to be determined with due attention to the effectiveness for weather-tightness, depending upon the type and the size of the hatch cover, as well as on the stiffness of the cover edges between the securing devices.

The net sectional area of each securing device is not to be less than:

A = 1.4 a / f [cm^2]

where:

a = spacing [m] of securing devices, not being taken less than 2 [m]

$f = (\sigma_Y / 235)^e$

σ_Y = specified minimum upper yield stress [N/mm^2] of the steel used for fabrication, not to be taken greater than 70% of the ultimate tensile strength.

$e = 0.75$ for $\sigma_Y > 235$

$= 1.0$ for $\sigma_Y \le 235$

Rods or bolts are to have a net diameter not less than 19 [mm] for hatchways exceeding 5 [m^2] in area.

Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weathertightness is to be maintained by the securing devices.

For packing line pressures exceeding 5 [N/mm], the cross section area is to be increased in direct proportion. The packing line pressure is to be specified.

The cover edge stiffness is to be sufficient to maintain adequate sealing pressure between securing devices. The moment of inertia, I, of edge elements is not to be less than:

$I = 6pa^4$ [cm^4]

p = packing line pressure [N/mm], minimum 5 [N/mm].

a = spacing [m] of securing devices.

Securing devices are to be of reliable construction and securely attached to the hatchway coamings, decks or covers. Individual securing devices on each cover are to have approximately the same stiffness characteristics.

Where rod cleats are fitted, resilient washers or cushions are to be incorporated.

Where hydraulic cleating is adopted, a positive means is to be provided to ensure that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

5.5.2 Stoppers

Hatch covers are to be effectively secured, by means of stoppers, against the transverse forces arising from a pressure of 175 [kN/m^2].

With the exclusion of No.1 hatch cover, hatch covers are to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 175 [kN/m^2].

No. 1 hatch cover is to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 230 [kN/m^2].

This pressure may be reduced to 175 [kN/m^2] when a forecastle is fitted in accordance with 1.4.

The equivalent stress:

i) in stoppers and their supporting structures, and

ii) calculated in the throat of the stopper welds

is not to exceed the allowable value of 0.8 σ_Y.

5.5.3 Materials and welding

Stoppers or securing devices are to be manufactured of materials, including welding electrodes, meeting relevant rule requirements.

5.6 Corrosion addition and steel renewal

5.6.1 Hatch covers

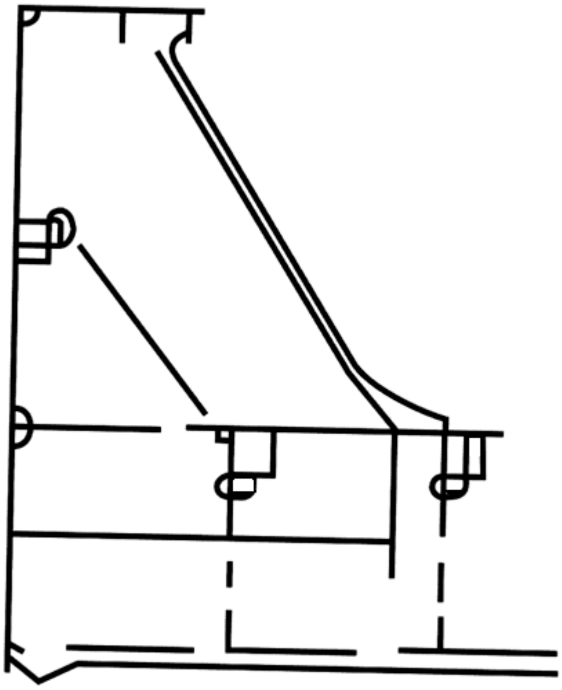
For all the structure (plating and secondary stiffeners) of single skin hatch covers, the corrosion addition t_c is to be 2.0 [mm].

For double skin hatch covers, the corrosion addition is to be:

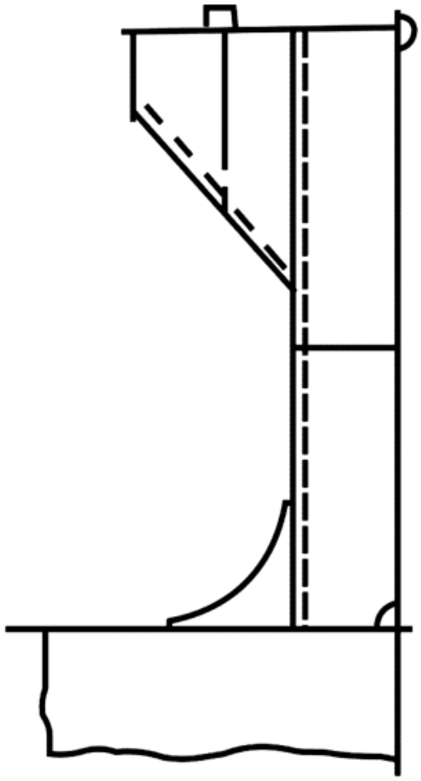
- 2.0 [mm] for the top and bottom plating
- 1.5 [mm] for the internal structures.

5.6.2 Hatch coamings

For the structure of hatch coamings and coaming stays, the corrosion addition t_c is to be 1.5 [mm].



a)



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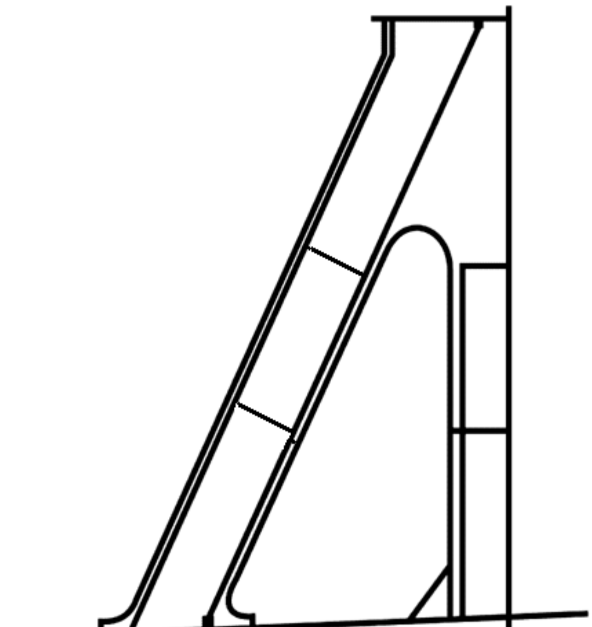

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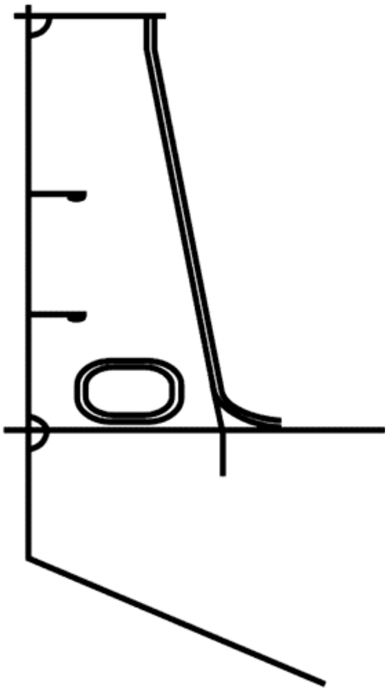

d)

End of Chapter

Chapter 2

Oil Tankers

Contents

Section 1

General

1.1 Application

1.1.1 The requirements of this chapter apply to sea going self-propelled ships which are constructed generally with integral tanks and intended primarily to carry crude oil or petroleum products in bulk having a flash point, F.P. (closed cup test) not exceeding 60°C and whose Reid vapour pressure is below the atmospheric pressure. These requirements are supplementary to those given for the assignment of main characters of class. The list of oils and petroleum products which can be carried in such vessels is given in Appendix A.

1.1.2 Other cargoes which may also be carried in these vessels are listed in Appendix B.

1.1.3 For oil tankers intended to carry liquids with flash point above 60°C, requirements pertaining to structural fire protection and safety may be equivalent to the requirements for dry cargo ships. However, in lieu of the fixed fire-extinguishing system they are to be provided with a fixed deck foam system complying with the requirements of Pt.6, Ch.8, Sec.14. When such cargoes are carried at an elevated temperature close to their flash point, the vessels will be specially considered.

1.1.4 Typical midship sections of oil tankers are shown in Fig.1.1.4.

1.1.5 The additional requirements given in Sec.12 apply to ships intended primarily to carry either oil in bulk with flash point below 60°C (closed cup test) or alternatively dry bulk cargo. Typical midship sections of such combination carriers are shown in Fig.1.1.5a (Ore or Oil Carriers) and Fig.1.1.5b (Oil or Bulk Carriers).

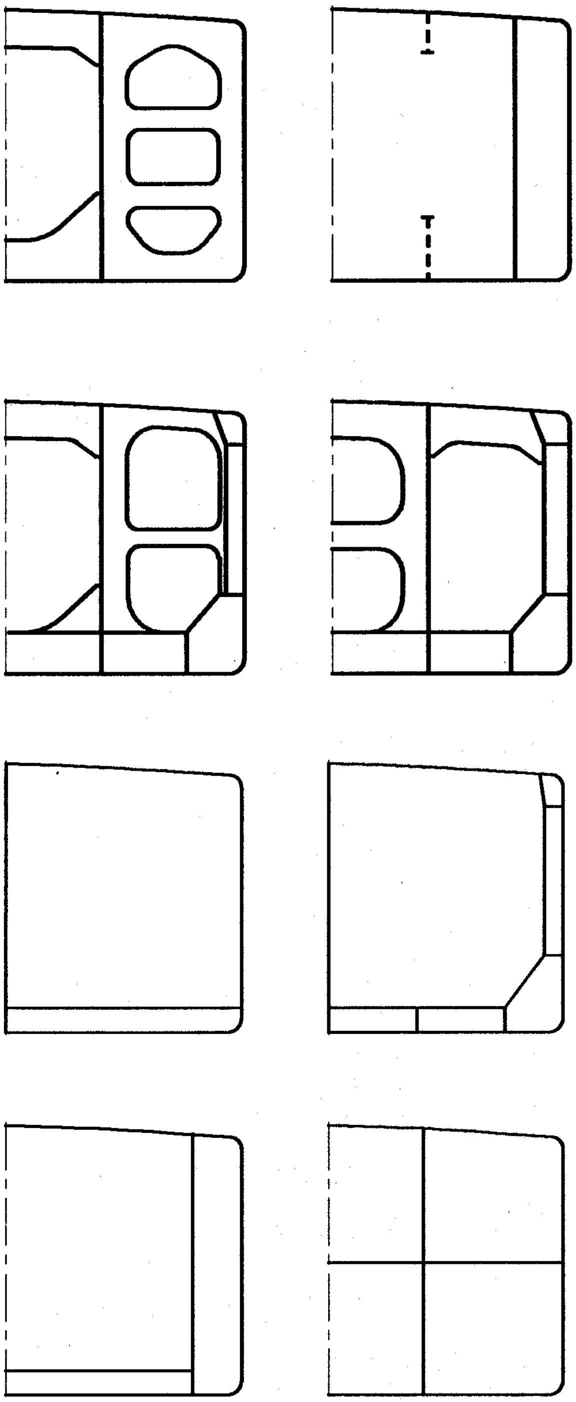

Fig.1.1.4. : Typical midship sections of oil tankers

1.1.6 The IACS common structural rules for oil tankers are to be applied to hull structures of double hull oil tankers of 150 [m] length and above for unrestricted service. Accordingly, for such vessels, the common structural rule requirements are to be applied instead of the requirements given in Section 3, 4 and 5 of this chapter.

1.1.7 Where the IACS common structural rules are applied as mentioned in 1.1.6 above, the vessel will be eligible to be assigned class notation '**CSR**'.

1.1.8 Assignment of class notation ESP (Enhanced Survey Program) is mandatory for oil tankers, ore or oil carriers and oil or bulk

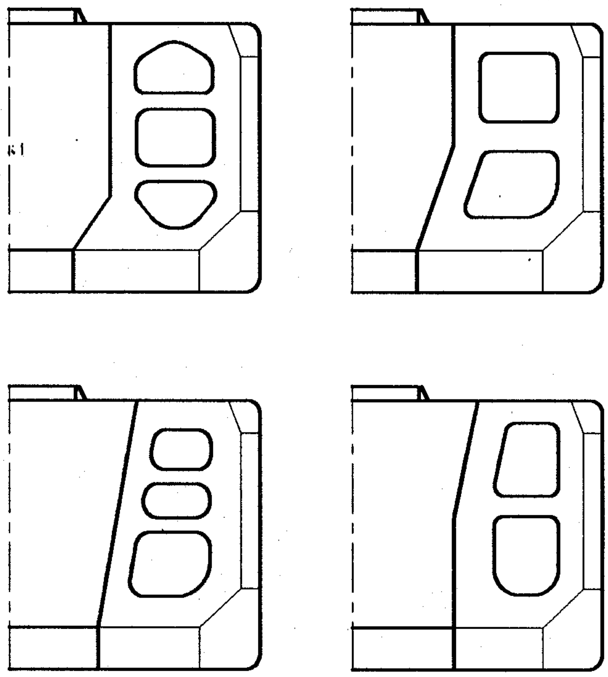

Fig.1.1.5(a) : Typical midship sections of ore or oil carriers

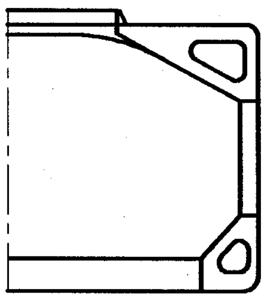

Fig.1.1.5(b) : Typical midship sections of oil or bulk carriers

carriers. For applicable enhanced survey requirements see Pt.1, Ch.2.

1.1.9 Oil tankers complying with above requirements will be eligible to be assigned class notation "**OIL TANKER, ESP**". For vessels designed for the carriage of liquid cargoes as per 1.1.2 or 1.1.3, the class notation will be suitably appended with "**For carriage of** ...... (to be specified) ..." or **"For carriage of liquid having F.P. above 60°C"** respectively.

1.1.10 Combination carriers as described in 1.1.5 will be eligible to be assigned class notation **"ORE OR OIL CARRIER, ESP" or "OIL OR BULK CARRIER, ESP".** Vessels also complying with appropriate additional requirements given in Pt.5, Ch.1 may be assigned additional class notations **"Strengthened for heavy cargoes"** or **"Strengthened for heavy cargoes, hold(s) ....** (to be specified) **... may be empty".**

1.1.11 The requirements of the following statutory regulation (as amended) are to be complied with in so far as they are applicable:

a) SOLAS 1974; Chapter II-1
- for general safety measures (construction, subdivision and stability, machinery and electrical installations);

b) SOLAS 1974; Chapter II-2
- for fire safety measures;

c) MARPOL; Annex (I)
- for ship arrangement (see 2.2.2) and pollution prevention;

d) MARPOL; Annex II
- for equipment when carrying noxious substance indicated in 1.1.2 above.

1.2 Documentation

1.2.1 Additional documents containing details of the items mentioned below are to be submitted for approval, as applicable.

- General Arrangement
    - cargo hatches, tank cleaning hatches and all other openings to cargo tank
    - doors, hatches and all other openings to gas dangerous zones
    - ventilation pipes and openings for cargo hatches, pump rooms and other gas dangerous spaces
    - doors, air locks, hatches, vent pipes and openings, openable hinged scuttles and other openings to gas-safe spaces adjacent to cargo area including spaces in and below forecastle deck
    - cargo oil pipes over the deck with shore connection
    - extent and location of gas-dangerous zones
- Capacity Plan
    - details of cargo tanks and segregated ballast tanks
- Access Plan
    - means of access to all spaces in cargo region and ballast spaces to meet the requirements of close-up survey
- Pumping and Piping Arrangements
    - cargo piping system including expansion element and flange connections
    - hydraulic system for cargo pump
    - bilge piping systems in pump rooms, cofferdams, pipe tunnels and other dry spaces in cargo area
    - permanent ballast piping in cargo area and arrangements in the forward and aft ends of the ship
- Electrical Installation
    - all electrical equipment in cargo area
    - area classification drawings
    - location of all electrical equipment in gas dangerous zone
    - single line diagrams for intrinsically safe circuits
    - list of explosion proof equipment with drawings and certificates
- Documents on
    - inert gas plant and piping system together with details of inert gas control and monitoring devices
    - crude oil washing system
    - slop tanks
    - cargo tank vents indicating the type and position of vent outlets from superstructure, erection, air intakes etc.
    - ventilation arrangement of cargo and/or ballast pump rooms and other enclosed spaces which contain cargo handling equipment
    - tank level gauges details
    - emergency towing arrangements.

1.2.2 Following documents are to be submitted for reference:

- A diagrammatic plan indicating compliance with the requirements of MARPOL Annex I, Regulation 19 regarding the dimensions of double bottom and wing tank spaces.
  When alternatives to double bottom or double hull as per the above regulations are

envisaged, details are to be submitted accordingly.

- Compliance with intact and damage stability requirements of the statutory authorities.

1.3 Materials and material protection

1.3.1 Materials used for the construction of hull, piping and fittings are to be compatible with the liquids and their vapours. Hatch packing materials should be resistant to the liquids and their vapours. Synthetic materials for components and piping are to be approved in each separate case.

1.3.2 Materials used in the inert gas system are to be suitable for their intended purpose.

1.3.3 Impressed current systems and magnesium or magnesium alloy anodes are not permitted in oil cargo tanks and in tanks adjacent to oil cargo tanks. Where aluminium anodes are fitted in oil cargo tanks and in tanks adjacent to oil cargo tanks, the installations are to satisfy the requirements of Pt.3, Ch.2, Sec.3.4.

1.3.4 Aluminium coatings containing greater than 10 percent aluminium by weight in the dry film are not to be applied in cargo tanks, cargo tank deck area, in pump rooms, cofferdams or any other spaces where flammable cargo vapour may accumulate.

1.3.5 Aluminised pipes may be permitted in ballast tanks, in inerted cargo tanks and, provided the pipes are protected from accidental impact, in hazardous areas on open deck.

1.4 Definitions

1.4.1 *Cargo area* is that part of the vessel that contains cargo tanks, slop tanks and cargo pump-rooms including, cofferdams, ballast and void spaces adjacent to cargo tanks and also deck areas throughout the entire length and breadth of the part of the ship over the above mentioned spaces.

1.4.2 *Slop tank* means a tank specifically designated for the collection of tank drainings, tank washings and other oily mixtures.

1.5 Intact stability of tankers during liquid transfer operations

1.5.1 All oil tankers of 5000 tonnes deadweight and above are to satisfy the requirements of intact stability during liquid transfer operations given in MARPOL, Annex I, Reg.27, where applicable. (For conditions of applicability see Reg.27).

All other tankers to which the MARPOL, Annex I, Reg.27 does not apply are to comply with the requirements given in 1.5.2 during liquid transfer operations which include cargo loading and unloading, lightering, ballasting and deballasting, ballast water exchange, and tank cleaning operations. Alternatively, requirements of MARPOL Annex I, Reg.27 could be applied as a matter of equivalence.

1.5.2 For any operating draught reflecting actual, partial or full load conditions, including the intermediate stages of liquid transfer operations the following intact stability criteria is to be complied with:

a) In port (see note below), the initial metacentric height GM_o is not to be less than 0.15 [m]. Positive intact stability is to extend from the initial equilibrium position at which GM_o is calculated over a range of at least 20 degrees to port and to starboard.

b) At sea, the intact stability criteria contained in paragraphs Chapter 3 of IMO Resolution A.749(18), the Intact Stability Code, or the criteria contained in the national requirements of the flag administration if the national stability requirements provide at least an equivalent degree of safety are to be complied with.

Note : At some port locations where the environmental conditions are similar to those at sea, the requirements given in para (b) are to be applied.

For all loading conditions in port and at sea, including intermediate stages of liquid transfer operations, the initial metacentric height and the righting lever curve are to be corrected for the effect of free surfaces of liquids in tanks.

1.5.3 For tankers to which MARPOL Annex I, Reg.27 has not been applied, the intact stability criteria specified in 1.5.2 is to be met preferably by design of the ship i.e. the design should allow for maximum free surface effects of all relevant slack tanks during the liquid transfer operations.

Where the intact stability criteria specified in 1.5.2 is not met through the design of the ship alone, the master is to be provided with clear instructions covering the operational restrictions and methods necessary to ensure compliance with the intact stability criteria. These instructions should be simple, clear and concise and shall provide pre-planned requirements for cargo/ballast transfer operations which satisfy the intact stability criteria.

Additionally, adequate instructions to enable pre-planning of other sequences of cargo/ballast transfer operations, which comply with the intact stability criteria throughout the operations, are to be provided. These instructions are to also provide for corrective actions to be taken by the officer-in-charge in case of unexpected technical difficulties in adhering to the pre-planned transfer sequences or in case of emergency situations.

These instructions are to be prominently displayed in the approved trim and stability booklet and at the cargo/ballast transfer control station. They are also to be included in any computer software available on board which is used for calculating and monitoring the intact stability or hull strength.

Section 2

Ship Arrangement

2.1 Location and separation of spaces

2.1.1 Location and separation of cargo spaces from machinery, accommodation, service spaces, control stations etc. are to be in accordance with Pt.6, Ch.2, Sec.1.5.

2.1.2 All dry spaces and tanks intended for water ballast which can remain empty in loaded condition are to be so arranged that they cannot be used for any other purpose.

2.1.3 Slop tanks are to be designed for efficient decantation. Positions of inlets, outlets, baffles and weirs where fitted, are to be located to ensure minimum turbulence and entrainment of oil or emulsion with water.

2.1.4 Cargo tanks are to be segregated from machinery spaces, accommodation spaces and other spaces of electrical hazard by means of cofferdams at least 760 [mm] in length and covering the whole area of the end bulkheads of cargo tanks. A pump room, oil fuel bunker or water-ballast tank will be accepted in lieu of a cofferdam. Oil engines or electrical equipment of potential fire hazard are not to be sited in these pump rooms or cofferdams.

2.1.5 Where a corner-to-corner situation occurs between a safe space and a cargo tank, the safe space is to be protected by a cofferdam. This protection may however be obtained by an angle bar or a diagonal plate across the corner. Such cofferdams, if accessible, is to be ventilated and if not accessible, is to be filled with a suitable and compatible compound.

2.1.6 A cofferdam between the forward cargo tank and the forepeak may be dispensed with, if:

- direct access is provided to the forepeak from the open deck,
- the air and sounding pipes to the forepeak space are led to the open deck, and
- portable means are provided for gas detection and inerting the forepeak compartment.

2.2 Tank arrangement

2.2.1 The disposition of transverse bulkheads should in general comply with the requirements of Pt.3, Ch.10, as applicable to ships with machinery aft.

2.2.2 The arrangement of the spaces within the cargo region with respect to the following features are to be in accordance with the MARPOL 73/78 (as amended), Annex I.

	Feature	Regulation
a)	Protection of cargo tank region with double bottom and wing ballast tank/spaces	19
b)	Segregated ballast tank (SBT)	18
c)	Protective location of SBT	18
d)	Crude oil washing (COW) (Crude carriers only),	33
e)	Segregation of fuel oil/ballast water	16
f)	Slop tanks and oil/water interface detectors	29
g)	Sludge tank for fuel oil	12
h)	Minimization of retention of oil on board	30(4) & (5)
i)	Tank size limitation / Accidental oil outflow performance	23
j)	Subdivision and damage stability	Reg.19, Reg.24 and Reg.28
k)	Intact stability	27
l)	Pump room bottom protection	22

2.2.3 The aggregate capacity of wing tanks, double bottom tanks, forepeak tanks and aft peak tanks intended to carry water ballast is not to be less than the capacity of segregated ballast tanks necessary to meet the requirements of MARPOL Annex I, Regulation 18.

2.2.4 Small tankers with single hull arrangements will be specially considered.

2.3 Arrangement for access in the cargo area and forward spaces

2.3.1 Each space is to be provided with a means of access to enable, throughout the life of a ship, overall and close-up inspections and thickness measurements of the ship's structures. Such means of access are to comply with the requirements of the technical provisions for means of access for inspections, specified in 2.4.

The technical provisions do not apply to cargo tanks of combined chemical/ oil tankers complying with Part 5 Ch.3. However, they are to be applied to ballast tanks in such vessels.

Each space for which close-up inspection is not required such as fuel oil tanks and void spaces forward of cargo area, may be provided with a means of a access necessary for overall survey intended to report on the overall conditions of the hull structure.

2.3.2 Where it is impracticable to fit permanent means of access, the provision of movable or portable means of access, as specified in 2.4 may be considered, provided that the means of attaching, rigging, suspending or supporting the portable means of access forms a permanent part of the ship's structure. All portable equipment is to be capable of being readily erected or deployed by ship's personnel.

2.3.3 The construction and materials of all means of access and their attachment to the ship's structure are to be approved by IRS.

2.3.4 Access to cofferdams, ballast tanks, cargo tanks and other spaces in the cargo area are to be direct from the open deck and such as to ensure their complete inspection. (For typical arrangement See Fig.2.3.4(a) and Fig.2.3.4(b)). Access to double bottom or to forward ballast spaces may be through a pump room, deep cofferdam, pipe tunnel, double hull space or similar compartment not intended for the carriage of oil or hazardous cargoes.

Every double bottom space is to be provided with separate access without having to pass through other neighbouring double bottom space.

The wording "not intended for the carriage of oil or hazardous cargoes" applies only to "similar compartments" i.e. safe access can be through a pump-room, deep cofferdam, pipe tunnel, cargo hold or double hull space.

2.3.5 Where a duct keel or pipe tunnel is fitted and access is normally required for operational purposes, access is to be provided at each end and at least one other location at approximately mid-length. Access is to be directly from the exposed deck. There is to be no connection to engine room. Where an after access is to be

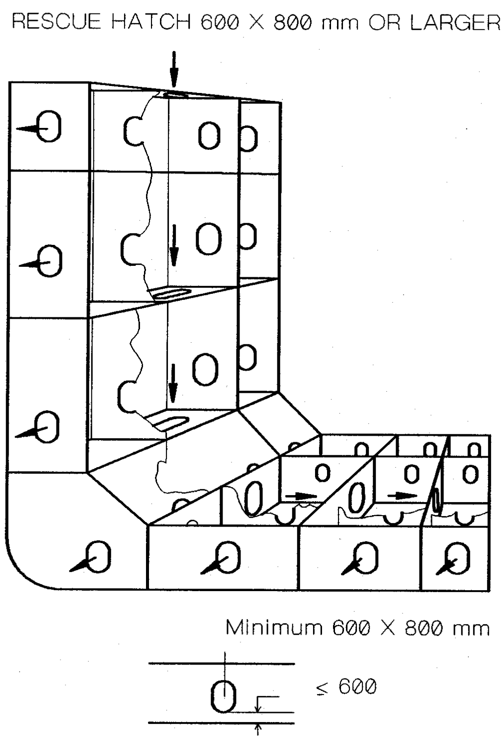

Fig.2.3.4(a): Access through side ballast space and double bottom

provided from the pump room to the duct keel, requirements of Pt.6, Ch.2, 1.5.2.4 are to be complied with. Mechanical ventilation is to be provided and such spaces are to be adequately ventilated prior to entry. A suitable notice is to be posted at the entry stipulating a sufficient period of ventilation prior to any attempt made to enter the space. In addition, the atmosphere in the tunnel is to be sampled by a reliable gas monitor, and when an inert gas system is fitted in the cargo tanks, an oxygen monitor is to be provided.

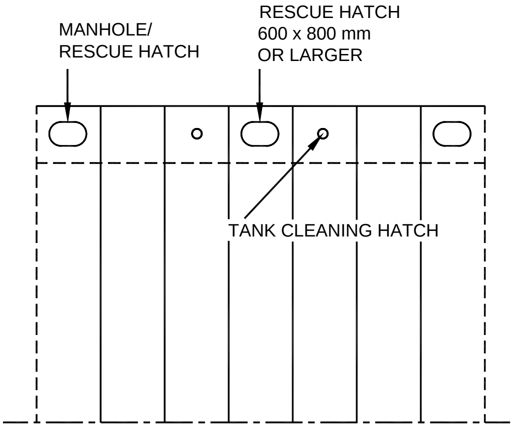

Fig.2.3.4(b) : Access arrangement through deck into wing bailast space

2.3.6 Tanks and subdivisions of tanks, having a length of 35 [m] or more are to be fitted with at least two access hatchways and ladders, as far apart as practicable. Tanks less than 35 [m] in length are to be served by at least one access hatchway and ladder. When a tank is subdivided by one or more swash bulkheads or similar obstructions which do not allow ready means of access to the other parts of the tank, at least two hatchways and ladders are to be fitted.

2.3.7 For access through horizontal openings, hatches or manholes, the dimensions shall be sufficient to allow a person wearing a self-contained, air-breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space.

2.3.8 A ship’s means of access to carry out overall and close-up inspections and thickness measurements is to be described in a Ship Structure Access Manual which is to consist of two parts.

The first part is to include the following for each space:

a) plans showing the means of access to the space, with appropriate technical specifications and dimensions;

b) plans showing the means of access within each space to enable an overall inspection to be carried out, with appropriate technical specifications and dimensions. The plans are to indicate from where each area in the space can be inspected;

c) plans showing the means of access within the space to enable close-up inspections to be carried out, with appropriate technical specifications and dimensions. The plans are to indicate the positions of critical structural areas, whether the means of access is permanent or portable and from where each area can be inspected. Critical structural areas are to be identified by advanced calculation techniques for structural strength and fatigue performance and service history of similar ships;

d) instruction for regularly inspecting and maintaining the structural strength of all means of access and means of attachment, taking into account any corrosive atmosphere that may be within the space;

e) instructions for safety guidance when rafting is used for close-up inspections and thickness measurements;

f) instructions for the rigging and use of any portable means of access in a safe manner;

g) an inventory of all portable means of access; and

The second part of the Ship Structure Access Manual is to contain a form of record of periodical inspections and maintenance, and change of inventory of portable equipment due to additions or replacement after construction. The format of this part is to be approved at the time of construction of the ship. The manual is to include a re-approval procedure for any changes to the permanent, portable or movable means of access.

The Ship Structure Access Manual is to be approved by IRS and an updated copy including all revisions / re-approvals is to be kept onboard.

2.4 Technical provisions for means of access for inspections

2.4.1 **Definitions** : For the purpose of these technical provisions the following definitions apply:

a) **Rung** means the step of a vertical ladder or step on the vertical surface.

b) **Tread** means the step of an inclined ladder or step for the vertical access opening.

c) **Flight of an inclined ladder** means the actual stringer length of an inclined ladder. For vertical ladders, it is the distance between the platforms.

d) **Stringer** means:

i) the frame of a ladder; or

ii) the stiffened horizontal plating structure fitted on the side shell, transverse bulkheads and/or longitudinal bulkheads in the space. For the purpose of ballast tanks of less than 5 [m] width forming double side spaces, the horizontal plating structure is credited as a stringer and a longitudinal permanent means of access, if it provides a continuous passage of 600 [mm] or more in width past frames or stiffeners on the side shell or longitudinal bulkhead. Openings in stringer plating utilized as permanent means of access are to be arranged with guard rails or grid covers to provide safe passage on the stringer or safe access to each transverse web.

e) **Vertical ladder** means a ladder of which the inclined angle is 70° and over upto 90°. A vertical ladder is not to be skewed by more than 2°.

f) **Overhead obstructions** means the deck or stringer structure including stiffeners above the means of access.

g) **Distance below deck head** means the distance below the plating.

2.4.2 Structural members subject to the close-up inspections and thickness measurements of the ship's structure referred to in Pt.1, Ch.2, except those in double bottom spaces are to be provided with a permanent means of access to the extent as specified in Table 2.4.2a and Table 2.4.2b, as applicable. Approved alternative methods such as rafting may be used in combination with the fitted permanent means of access, provided that the structure allows for its safe and effective use.

2.4.3 Permanent means of access should as far as possible be integral to the structure of the ships, thus ensuring that they are robust and at the same time contributing to the overall strength of the structure of the ship.

2.4.4 Elevated passageways forming sections of a permanent means of access, where fitted are to have a minimum clear width of 600 [mm], except for going around vertical web where the minimum clear width may be reduced to 450 [mm] and have guard rails over the open side of their entire length. Sloping structures providing part of the access that are sloped 5 degrees or more from the horizontal plane are to be of a non-skid construction. Non-skid construction is to be such that the surface on which the personnel walks provides sufficient friction to the sole of boots even when the surface is wet and covered with thin sediment.

Guard rails are to be atleast 1000 [mm] in height and consist of a rail and an intermediate rail. Guard rails are to be fitted on the open side. For stand alone passageways guard rails are to be fitted on both sides of these structures. Guardrail stanchions are to be attached to the permanent means of access. The distance between the passageway and the intermediate rail and the distance between intermediate rail and the top rail shall not be more than 500 [mm]. They are to be of substantial construction ensuring adequate design strength as well as residual strength during service life. Stanchions are to be not more than 3 [m] apart. Discontinuous handrails are allowed provided the gap does not exceed 50 [mm]. (See Fig.2.4.4). The distance between adjacent stanchions across the handrail gaps is to be not more than 350 [mm].

Durability of passage ways and guard rails are to be ensured by corrosion protection and inspection and maintenance during services. Use of alternative materials such as GRP are to be subject to compatibility with the liquid carried in the tank. Fire resistant materials are to be used for all means of access.

Table 2.4.2a : Means of access for ballast and cargo tanks of oil tankers
Access to the underdeck and vertical structure

Water ballast wing tanks of less than 5 [m] width forming double side spaces and their bilge hopper sections

Double side spaces above hopper side tank

1. **For double side spaces above the upper knuckle point** of the bilge hopper sections, permanent means of access are to be provided in accordance with 1.1 to 1.3:

1.1 where the vertical distance between horizontal uppermost stringer and deck head is 6 [m] or more, one continuous longitudinal permanent means of access is to be provided for the full length of the tank with a means to allow passing through transverse webs installed at a minimum of 1.6 [m] to a maximum of 3 [m] below the deck head with a vertical access ladder at each end of the tank;

1.2 continuous longitudinal permanent means of access, which are integrated in the structure, at a vertical distance not exceeding 6 [m] apart; (when the permanent means of access is integral with the structure, the allowable vertical distance may be increased by 10%) and

1.3 plated stringers are as far as possible, be in alignment with horizontal girders of transverse bulkheads.

Notes:

a) 1.1 above is for access to under deck structures, whereas 1.2 is for access for inspection of vertical structures (transverse webs) on longitudinal bulkheads.

b) 1.1 to 1.3 above are also applicable to wing tanks designed as void spaces

c) For a tank where the vertical distance between horizontal upper stringer and deck head varies at different sections item 1.1 is to be applied to such sections which fall under the criteria.

d) The continuous permanent means of access may be a wide longitudinal, which provides access to critical details on the opposite side by means of platforms as necessary on web frames. In case the vertical opening of the web frame is located in way of the open part between the wide longitudinal and the longitudinal on the opposite side, platforms shall be provided on both sides of the web frames to allow safe passage through the web frame.

e) Where two access hatches are required by clause 2.3.6, access ladders at each end of the tank are to be led to the deck.

Hopper side tanks of height ≥ 6 [m]

2. For bilge hopper sections of which the vertical distance from the tank bottom to the upper knuckle point is 6 [m] and over, one longitudinal permanent means of access is to be provided for the full length of the tank. It is to be accessible by vertical permanent means of access at each end of the tank.

Table 2.4.2a (Contd.)

Notes:

a) Permanent means of access is to be provided between the longitudinal continuous permanent means of access and the bottom of the space.

b) The height of a bilge hopper tank located outside of the parallel part of vessel is to be taken as the maximum of the clear vertical distance measured from the bottom plating to the hopper plating of the tank.

c) The foremost and aftmost bilge hopper ballast tanks with raised bottom, of which the height is 6 [m] and over, a combination of transverse and vertical means of access to the upper knuckle point for each transverse web may be accepted in place of the longitudinal permanent means of access.

2.1 The longitudinal continuous permanent means of access may be installed at a minimum 1.6 [m] to maximum 3 [m] from the top of the bilge hopper section. In this case, a platform extending the longitudinal continuous permanent means of access in way of the web frame may be used to access the identified structural critical areas.

2.2 Alternatively, the continuous longitudinal permanent means of access may be installed at a minimum of 1.2 [m] below the top of the clear opening of the web ring allowing a use of portable means of access to reach identified structural critical areas.

Hopper side tanks of height < 6 [m]

3. Where the vertical distance referred to in 2 is less than 6 [m], alternative means as defined in 2.4.10 or portable means of access may be utilized in lieu of the permanent means of access. To facilitate the operation of the alternative means of access, in-line openings in horizontal stringers are to be provided. The openings are to be of an adequate diameter and are to have suitable protective railings.

Table 2.4.2b : Means of access for ballast and cargo tanks of oil tankers
Access to the underdeck and vertical structure

Water ballast tanks, except those specified in Table 2.4.2a and cargo oil tanks

Tanks of height ≥ 6 [m]

1. **For tanks of which the height is 6 [m] and over** containing internal structures, permanent means of access is to be provided in accordance with 1.1 to 1.6:

1.1 continuous athwartship permanent access arranged at each transverse bulkhead on the stiffened surface, at a minimum of 1.6 [m] to a maximum of 3 [m] below the deck head;

1.2 at least one continuous longitudinal permanent means of access at each side of the tank. One of these accesses is to be at a minimum of 1.6 [m] to a maximum of 6 [m] below the deck head and the other is to be at a minimum of 1.6 [m] to a maximum of 3 [m] below the deck head;
(1.2 is applicable also when the deck longitudinals and deck transverses are fitted on deck but the supporting brackets are fitted under the deck)

1.3 access between the arrangements specified in 1.1 and 1.2 and from the main deck to either 1.1 or 1.2;

1.4 continuous longitudinal permanent means of access which are integrated in the structural member on the stiffened surface of a longitudinal bulkhead, in alignment, where possible, with horizontal girders of transverse bulkheads, are to be provided for access to the transverse webs unless permanent fittings are installed at the upper most platform for use of alternative means, as defined in 2.4.10 for inspection at intermediate heights; (rafting is not acceptable for this purpose)

For water ballast tanks of 5 [m] or more in width, such as on an ore or oil carrier, side shell plating shall be considered in the same way as “longitudinal bulkhead”.

1.5 for ships having cross-ties which are 6 [m] or more above tank bottom, a transverse permanent means of access on the cross-ties providing inspection of the tie flaring brackets at both sides of the tank, with access from one of the longitudinal permanent means of access in 1.4;

1.6 alternative means as defined in 2.4.10 may be provided for small ships as an alternative to 1.4 for cargo oil tanks of which the height is less than 17 [m].

Notes:

a) 1.1, 1.2 and 1.3 above are for access to underdeck structure, uppermost sections of transverse webs and connection between these structures

b) 1.4, 1.5 and 1.6 above are meant for access to vertical structures only and are linked to the presence of transverse webs on longitudinal bulkheads.

c) If there are no underdeck structures (deck longitudinals and deck transverses) but there are vertical structures in the cargo tank supporting transverse and longitudinal bulkheads, access in accordance with 1.1 to 1.6 is to be provided for inspection of the upper parts of vertical structure on transverse and longitudinal bulkheads.

d) If there are no stiffening structures inside the cargo tank, 1.1 to 1.6 are not applicable.

e) The requirements in 1.1 to 1.6 are also to be applied to void spaces of comparable volume in the cargo area.

Table 2.4.2b (Contd.) f) The vertical distance below the overhead structure is to be measured from the underside of the main deck plating to the top of the platform of the means of access at a given location g) The height of the tank is to be measured at each tank. For a tank where the height varies at different bays, the requirements are to be applied to only such bays of a tank that have height 6 [m] and over.
Tanks of height < 6 [m] 2. For tanks of which the height is less than 6 [m], alternative means as defined in 2.4.10 or portable means may be utilized in lieu of the permanent means of access.
Fore peak tanks 3. For fore peak tanks with a depth of 6 [m] or more at the centre line of the collision bulkhead, a suitable means of access is to be provided for access to critical areas such as the underdeck structure, stringers, collision bulkhead and side shell structure. 3.1 Stringers of less than 6 [m] in vertical distance from the deck head or a stringer immediately above are considered to provide suitable access in combination with portable means of access. 3.2 In case the vertical distance between the deck head and stringers, stringers or the lowest stringer and the tank bottom is 6 [m] or more, alternative means of access as defined in 2.4.10 is to be provided.

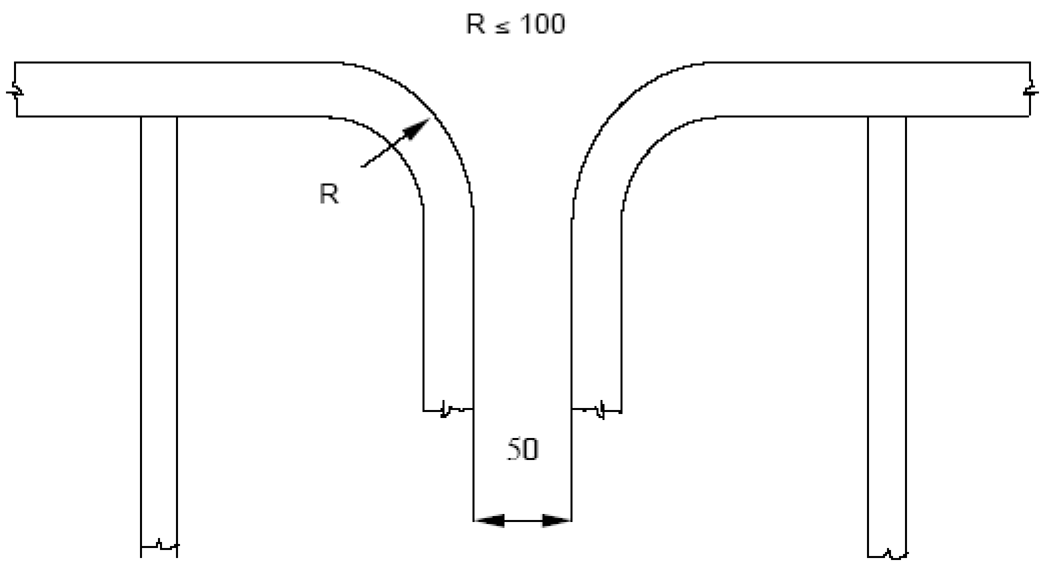

Fig.2.4.4

2.4.5 Access to permanent means of access and vertical openings from the ship's bottom is to be provided by means of easily accessible passageways, ladders or treads. Treads are to be provided with lateral support for the foot. Where the rungs of ladders are fitted against a vertical surface, the distance from the centre of the rungs to the surface is to be at least 150 [mm]. Where vertical manholes are fitted higher than 600 [mm] above the walking level, access are to be facilitated by means of treads and hand grips with platform landings on both sides. In such cases it is to be demonstrated that an injured person can be easily evacuated.

2.4.6 Permanent inclined ladders are to be inclined at an angle of less than 70°. There are to be no obstructions within 750 [mm] of the face of the inclined ladder, except that in way of an opening this clearance may be reduced to 600 [mm]. Resting platforms of adequate dimensions are to be provided, normally at a maximum of 6 [m] vertical height. Ladders and handrails are to be constructed of steel or equivalent material of adequate strength and stiffness and securely attached to the structure by stays. The method of support and length of stay are to be such that vibration is reduced to a practical minimum.

2.4.7 The width of inclined ladders between stringers are not to be less than 400 [mm]. The treads are to be equally spaced at a distance apart, measured vertically of between 200 [mm] and 300 [mm]. When steel is used, the treads are to be formed of two square bars of not less than 22 [mm] by 22 [mm] in section fitted to form a horizontal step with the edges pointing upward. The treads are to be carried through the side stringers and attached thereto by double continuous welding. All inclined ladders are to be provided with two course handrails of substantial construction on both sides, fitted at a convenient distance above the treads. Vertical height of handrails is not to be less than 890 [mm] from the center of the step and two course handrails need only be provided where the gap between stringer and top handrail is greater than 500 [mm].

2.4.8 For vertical ladders or spiral ladders, the width and construction are to be in accordance with international or national standards.

The width of vertical ladders is to be not less than 350 [mm] and the vertical distance between the rungs is to be between 250 [mm] and 350[mm]. The minimum climbing clearance in width is to be 600[mm].
The vertical ladders are to be secured at intervals not exceeding 2.5 [m] apart to prevent vibration.

2.4.9 No free-sanding portable ladder is to be more than 5 [m] long. Mechanical devices such as hooks for securing the upper end of a ladder is considered as an appropriate securing device if movement fore/ aft and sideways can be prevented at the upper end of the ladder.

2.4.10 Alternative means of access include, but are not limited to, such devices as:

a) hydraulic arm fitted with a stable base;
b) wire lift platform;
c) staging;
d) rafting;
e) robot arm or remotely operated vehicle (ROV);
f) portable ladders (ladders of more than 5 [m] long are to be utilized only if fitted with a mechanical device to secure the upper end of the ladder);
g) other means of access, approved by and acceptable to IRS.

(Refer to Classification Notes : "Guidelines for approval / acceptance of alternative means of access to spaces in oil tankers, bulk carriers, ore carriers and combination carriers").

Means for safe operation and rigging of such equipment to and from and within the spaces are to be clearly described in the Ship Structure Access Manual.

Where an unmanned robot arm or ROVs are proposed to be used for overall and close-up surveys and thickness measurements of deck head structure such as deck transverses and deck longitudinals of cargo oil tanks and ballast tanks, they are to be capable of:

a) safe operation in ullage space in gas free environment; and
b) introduction into the place directly from a deck access.

2.4.11 For access through horizontal openings, hatches or manholes, the minimum clear opening is not to be less than 600 [mm] x 600 [mm], which may have corner radii of not more than 100 [mm]. Where a larger corner sections is desired to reduce the stress level around the opening, the size of the opening is to be suitably increased to ensure the required size of clear opening e.g. 600 [mm] x 800 [mm] opening with 300 [mm] corner radius is acceptable.

2.4.12 For access through vertical openings, or manholes, in swash bulkheads, floors, girders and web frames providing passage through the length and breadth of the space, the minimum opening is not to be less than 600 [mm] x 800 [mm] at a height of not more than 600 [mm] from the passage unless gratings or other foot holds are provided.

The opening of 600 [mm] x 800 [mm] may have corner radii of 300 [mm]. An opening of 600 [mm] in height x 800 [mm] in width may be accepted as access opening in vertical structures where it is not desirable to make large opening considering structural strength aspects, such as in girders and floors in double bottom tanks.

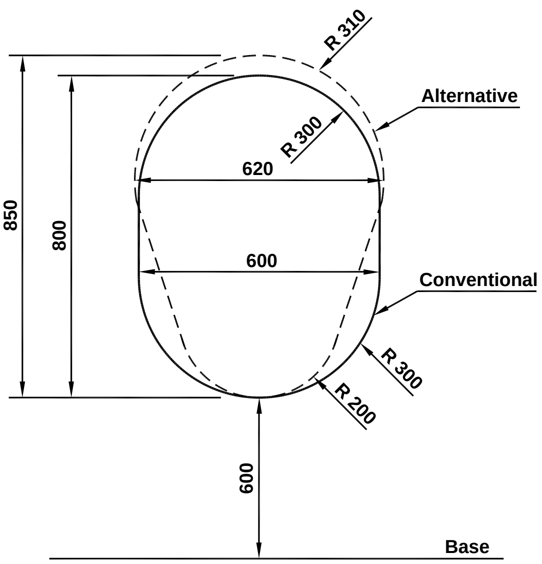

Fig.2.4.12 : Access opening in vertical structure

Subject to verification of easy evacuation of injured person on a stretcher, a vertical opening 850[mm] x 620 [mm] as shown in Fig.2.4.12 is considered as an acceptable alternative to the opening of 600 [mm] x 800 [mm] height with corner radii of 300 [mm].

2.4.13 For oil tankers of less than 5,000 tonnes deadweight, in special circumstances, smaller dimensions may be accepted for the openings referred to in 2.4.11 and 2.4.12, if the ability to traverse such openings or to remove an injured person can be proven.

2.4.14 In tanks and subdivisions of tanks having a length of 35 [m] or more requiring two accesses, one access is to consist of inclined ladder or ladders and for the other access a vertical ladder may be used as follows:

a) Where an inclined ladder or combination of ladders is used for access to the space, the uppermost section of the ladder, measured clear of the overhead obstructions in way of the tank entrance, is to be vertical for not less than 2.5 [m] but not exceeding 3.0 [m] and is to comprise of a landing platform continuing with an inclined ladder. However, the vertical distance of the upper most section of the vertical ladder may be reduced to 1.6 [m], if the ladder lands on a longitudinal or athwartship permanent means of access fitted within that range. The flights of the inclined ladders are normally to be not more than 6 [m] in vertical height. The lowermost section of the ladders may be vertical for a distance not exceeding 2.5 [m].

b) Where vertical ladders are used for access and the vertical distance is more than 6 [m], they are to comprise of one or more ladder linking platforms spaced not more than 6 [m] apart vertically and displaced to one side of the ladder. The uppermost entrance section from deck of the vertical ladder providing access to a tank is to be vertical for a distance of 2.5 [m] but not exceeding 3.0 [m] measured clear of overhead obstructions and comprise a ladder linking platform, displaced to one side of a vertical ladder. The vertical distance of the uppermost section of the ladder may be reduced to 1.6 [m] if it lands on a longitudinal or athwartship permanent means of access fitted within that range.

2.4.15 In tanks of less than 35 [m] in length served by one access hatchway, an inclined ladder or combination of ladders are to be used as specified in 2.4.14 (a) above.

2.4.16 In spaces of less than 2.5 [m] width, the access to the space may be by means of vertical ladders as specified in 2.4.14.(b) above. Adjacent sections of ladder are to be laterally offset from each other by at least the width of the ladder.

2.4.17 Access from deck to a double bottom space may be by means of vertical ladders through a trunk, with resting platforms spaced not more than 6 [m] vertically.

2.5 Equipment in tanks and cofferdams

2.5.1 Anodes, crude oil washing machines and other permanently attached equipment units in tanks and cofferdams are to be firmly secured to the structure. The units and their supports are to be able to withstand sloshing in the tanks and vibratory loads as well as other loads which may be imposed in service. Due consideration should be paid to anti-spark properties of the materials in these permanently attached equipment in tanks and cofferdams. The fixed tank washing machines are to be permanently earthed to the ship.

2.6 Chain locker, anchor windlass and emergency fire pump

2.6.1 The chain locker, anchor windlass and diesel engines for emergency fire pumps are to be installed outside spaces susceptible to the danger of fire and explosion. The distance from the nearest tank hatch or cargo tank opening to windlass and chain pipe is not to be less than 6.0 [m]. (Also see Cl.8.1.15(c)).

2.6.2 The exhaust pipe of the diesel engine is to have an effective spark arrester and is to be led out to the atmosphere well outside the cargo area and away from all possible sources of fire and explosion.

2.7 Testing of cargo, ballast tanks and other spaces in cargo region

2.7.1 The procedure for testing of cargo tanks and ballast and other spaces in the cargo region are to be generally in accordance with Pt.3, Ch.18.

Due consideration may however be given in cases where the procedures are rendered impracticable due to large size of the tanks.

2.8 Emergency towing arrangements

2.8.1 All tankers of deadweight 20,000 tonnes and above are to be provided with emergency towing arrangements at forward and aft ends. Emergency towing arrangements are to be of adequate strength taking into account the size and deadweight of the ship and the expected forces during bad weather conditions. The design, construction and prototype testing of emergency towing arrangements are to be approved by IRS.

2.8.2 The arrangements, at all times are to be capable of rapid deployment in the absence of main power on the ship to be towed and easy connection to the towing ship. At least one of the emergency towing arrangements are to be pre-rigged, ready for rapid deployment.

2.8.3 Towing pennant, chafing gear, fairleads and strong points on the ship are to have a minimum working strength as follows:

DWT [tonnes]	SWL* [kN]
≥ 20,000 and < 50,000	1000
≥ 50,000	2000
* SWL : 0.5 x Ultimate Strength	

The strength of towing components and their supporting structure is also to be sufficient for all relevant angles of towline, i.e. upto 90° from the ship's centreline to port and starboard and upto 30° vertically downwards from horizontal.

2.8.4 Chafing chain for emergency towing arrangements

a) **Scope** : These requirements apply to the chafing chain for chafing gear of two types of emergency towing arrangement (ETA) with specified safe working load (SWL) of 1000 [kN] (ETA1000) and 2000 [kN] (ETA2000). Chafing chains other than those specified can be used subject to special approval by IRS.

b) Approval of manufacturing, materials used for the manufacture of the chafing chain, design, manufacture, testing and certification of chafing chain are to be in accordance with Part 2, Chapter 10, Section 2.

c) The arrangement at the end connected to the strong point and the dimensions of the chafing chain are determined by the type of ETA. The other end of the chafing chain is to be fitted with a pear-shaped open link allowing connection to a shackle corresponding to the type of ETA and chain cable grade. A typical arrangement of this chain end is shown in Fig.2.8.4.

d) The common link is to be of stud link type grade 2 or 3.

e) The chafing chain is to be able to withstand a breaking load not less than twice the SWL. For each type of ETA, the nominal diameter of common link for chafing chains is to comply with the value indicated in the following table:

Nominal diameter of common link for chafing chains		
Type of ETA	**Nominal diameter of common link, d min.**	
	Grade CC2	**Grade CC3**
ETA 1000	62 [mm]	52 [mm]
ETA 2000	90 [mm]	76 [mm]

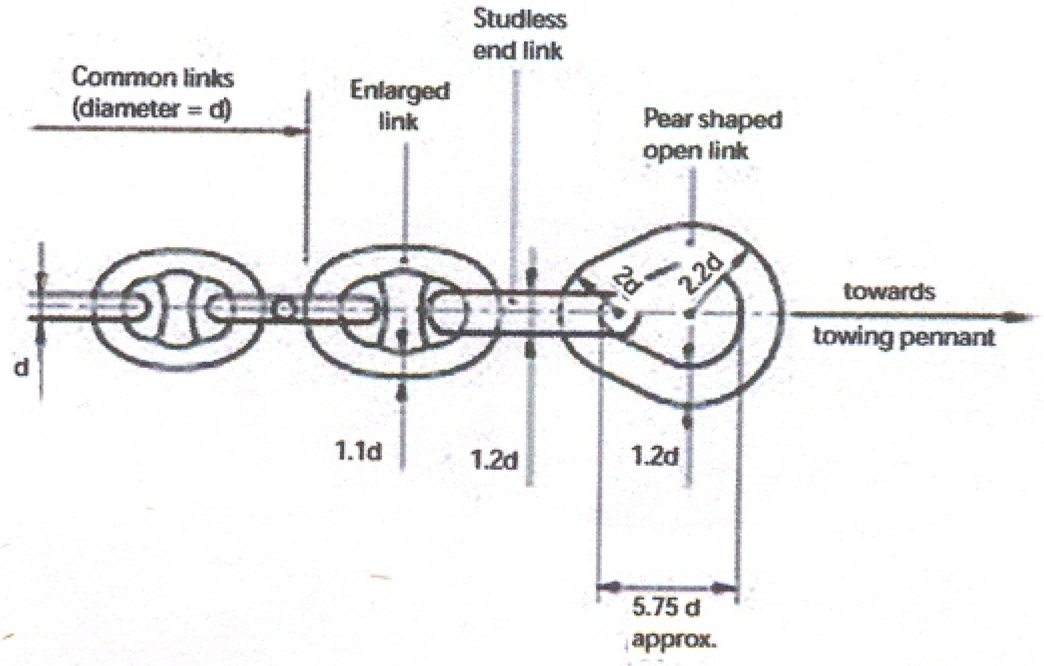

Fig.2.8.4 : Typical outboard chafing chain end

2.9 Cargo manifold gutter bars - freeing arrangements and intact stability

2.9.1 Where gutter bars are installed on the weather decks of tankers in way of cargo manifolds and are extended aft as far as the after house front for the purpose of containing cargo spills on deck during loading and discharge operations the free surface effects caused by containment of a cargo spill during liquid transfer operations or of boarding seas while underway require consideration with respect to the vessel's available margin of positive initial stability (GMo).

2.9.2 Where the gutter bars installed are greater than 300 [mm] in height, they are to be treated as bulwarks according to the Load Line Convention, with freeing ports arranged in accordance with Pt.3, Ch.11, Sec.5.4 and effective closures provided for use during loading and discharge operations. Attached closures are to be arranged in such a way that jamming cannot occur while at sea, ensuring that the freeing ports will remain fully effective.

2.9.3 On ships without deck camber, or where the height of the installed gutter bars exceeds the camber, and for tankers having cargo tanks exceeding 60% of the vessel's maximum beam at midships regardless of gutter bar height, an assessment of the initial stability (GM_o) for compliance with the relevant intact stability requirement taking into account the free surface effect caused by liquids contained by the gutter bars will be required if gutter bars are provided.

Section 3

Longitudinal Strength

3.1 General

3.1.1 The longitudinal strength is to be determined as per Pt.3, Ch.5.

3.1.2 The read-out points for loading instruments fitted in accordance with Pt.3, Ch.5 are to be positioned at the transverse bulkheads. In general, except when the instrument calculates the maximum values between read-out points, the spacing of read-out points within the cargo tank length is not to exceed five percent of the ship length with intermediate points arranged between bulkheads as necessary.

3.2 Loading conditions

3.2.1 Where a double bottom tank is omitted in accordance with MARPOL Annex I, Reg. 19(4)(1), the minimum operating draught in any loading condition is to be indicated on the midship section plan, loading manual and loading instrument.

3.2.2 Conditions which provide for wing and centre cargo tanks abreast to be filled, with adjacent wing and centre cargo tanks empty, should be avoided as far as possible. Similarly, conditions which provide for differential loading of port and starboard wing cargo tanks with centre cargo tanks empty should also be avoided as far as possible. Where such conditions are contemplated, they will be subject to special consideration.

3.2.3 When loading conditions envisage partially filled tanks, attention is drawn to the need to ensure that the boundary bulkheads are capable of withstanding the loads imposed by the movement of liquid in the tanks.

Section 4

Hull Structure

4.1 General

4.1.1 The bottom shell, inner bottom and deck are generally to be longitudinally framed in the cargo tank region. For ships length L > 150 [m], the side shell, inner hull and longitudinal bulkheads are also to be longitudinally framed. The longitudinal bulkheads may however, be horizontally corrugated provided the ship's length does not exceed 200 [m].

4.1.2 Inner hull and longitudinal bulkheads are to extend beyond the cargo tank region as far forward and aft as practicable and are to be effectively scarfed into the adjoining structure.

4.1.3 Primary members are to be so arranged as to ensure effective continuity of strength throughout the tank structure. Abrupt changes in depth of sections are to be avoided. Vertical webs on structure are to be arranged in line with the double bottom floors, deck transverses and vertical transverses at the longitudinal bulkheads to ensure continuity of transverse structure.

Longitudinal deck girders are to be supported at transverse bulkheads by vertical webs or equivalent. The depth and scantlings of the continuous girders are to be increased in way to provide effective support.

Where members abutt on both sides of bulkhead or other deeper members, the alignment of webs and faceplates are to be ensured.

4.1.4 The minimum thickness requirement of all structural parts in the cargo tank region is

$$t = (5.0 + 0.02L)\sqrt{k} + t_c \text{ [mm]}$$

where, k and t_c are to be obtained from Pt.3, Ch.2.

4.1.5 The arrangement and scantlings of all tank boundary panels are to be capable of withstanding the dynamic loads from the liquids inside the tanks. Where tanks are intended to be partially filled, the scantling calculations together with the predicted dynamic loadings are to be submitted.

4.2 Bottom structure

4.2.1 The scantlings and arrangements are, in general, to be as per Pt.3, Ch.7 except as given below.

4.2.2 The strengthening of bottom forward is to be based on the minimum draught forward obtained using segregated ballast tanks only.

4.2.3 Longitudinal girders are to be provided at

- centreline (or duct keel)
- under longitudinal bulkhead (or sloping plates of bulkhead stool in case of vertically corrugated longitudinal bulkheads)
- under sloping plate of hopper side tank where fitted.

4.2.4 In way of vertically corrugated transverse bulkheads supported by stools, additional longitudinal girders are to be arranged extending at least to the first plate floor adjacent to the bulkhead stool sloping plates on each side. These girders are to be spaced not more than 3.6 [m] apart.

4.2.5 Plate floors are to be arranged in way of transverse bulkheads and sloping plates of bulkhead stools.

4.2.6 The inner bottom plating thickness and longitudinals are also to comply with the requirements for cargo tank boundaries as given in Pt.3, Ch.10.

4.2.7 Transverse continuity of inner bottom is to be maintained outboard of inner hull.

4.3 Side structure

4.3.1 Where a hopper side tank is fitted, a transverse is to be arranged in the hopper tank in line with each double bottom plate floor. Scarfing brackets are to be fitted in the hopper in line with the inner bottom on both sides of each transverse to ensure continuity of the inner bottom plating into the hopper side tank. Longitudinal knuckles in the hopper tank plating are to be adequately supported. A horizontal girder is to be arranged at the top of the hopper space and is to be located close to the knuckle between the hopper and the inner hull. Where additional longitudinal girders are provided to satisfy access requirements as per 2.3.7, these are to be arranged in line with horizontal girders on the transverse bulkhead and wing tank cross ties where fitted.

4.3.2 The scantlings of vertical webs and horizontal girders are to be determined by means of direct calculations.

4.3.3 The sectional areas of the cross ties connecting the side transverses to the vertical webs on inner hull or longitudinal bulkheads effectively are not to be less than required in Pt.3, Ch.3, Sec.6.

4.3.4 Brackets are to be provided at the ends of the crossties to connect to the transverses or girders. Transverses and vertical webs are to be fitted with tripping brackets at the junctions with cross ties. Where the width of the face plate of the cross ties exceeds 150 [mm] on any one side of the web, additional tripping brackets are to be provided to support the face plate.

4.3.5 End connections of cross-ties are to ensure adequate area of connection and may require additional bracket thickness. Full penetration welding may be required particularly in way of toes of the end brackets.

4.4 Deck structure

4.4.1 Where small diameter threaded openings are arranged on the upper decks for staging wires, these are to be located clear of the other openings and similar areas of stress concentration. Care is to be taken to ensure a gradual transition at the thread ends and the edges of the holes are to be ground smooth. The closing arrangements are to be as per 2.3.8.

4.4.2 The scantlings of deck transverses and girders are to be determined by means of direct calculations.

4.4.3 A trunk deck, if fitted is to extend over the full length of the cargo tanks and is to be effectively scarfed into the main hull structure. The trunk deck and the sides are to be longitudinally framed and the transverse primary members are to be aligned with the outboard deck transverses.

4.4.4 Where external stiffening is carried in way of the trunk deck, appropriate tripping brackets are to be fitted in way of the underdeck supporting structure. The arrangement and details of the external girders will be specially considered.

4.4.5 The thickness of the trunk top and side plating as well as the scantlings of the stiffeners and girders are to be obtained as per Pt.3, Ch.8 & 9 respectively.

4.5 Tank bulkheads

4.5.1 The arrangement and stiffening of transverse oil tight bulkheads are to efficiently support the lateral liquid pressure as well as the loads transmitted by end connection of inner hull, longitudinal bulkheads, shell and deck longitudinals. Where transverse bulkheads are vertically corrugated, horizontal stringers or equivalent are to be fitted to provide adequate resistance to transverse compressive forces.

4.5.2 The top and bottom strakes of longitudinal corrugated bulkheads are to be plane over width of 0.1D from the deck and bottom. The thickness of this plating is not to be less than 75% of the adjoining deck and inner bottom plating.

4.5.3 Particular attention is to be paid to the through thickness properties at the connection to the deck and inner bottom.

4.5.4 Where longitudinal bulkheads are corrugated horizontally, the corrugations are to be aligned, and stiffening arrangements on plane members are to be arranged to provide adequate support in way of flanges of abutting corrugations. Where both the longitudinal and transverse bulkheads are horizontally corrugated, the ends are to be connected to ensure continuity.

4.5.5 Bulkhead stools in way of vertically corrugated bulkheads where fitted are to be generally as per Pt.5, Ch.1, Sec.2.9. An efficient system of reinforcement is to be arranged in line with the tank transverse bulkheads or bulkhead stools at the intersection with the sloped plating of double bottom hopper tanks and topside tanks.

4.5.6 The arrangement of stools and adjacent structure common to the cargo tank is to be designed to avoid pockets in which gas could collect.

4.5.7 Non-oil tight wash bulkheads are generally to be of plane construction having an area of perforation between 5 to 10 percent of the total area of the bulkhead. Large perforations should not be provided on the top and bottom strakes of longitudinal bulkheads. The stiffening arrangement and the perforations are to be arranged so as not to impair strength of the bulkhead and provide adequate support to the loads from the end connections. Where tanks are intended to be partially filled, the scantlings and arrangement are to be capable of withstanding the dynamic loads.

4.5.8 The plate thickness of wash bulkheads is not to be less than the minimum thickness specified in 4.1.4. Where the wash bulkheads support primary members perpendicular to their plane, the plating with stiffeners are to have adequate shear rigidity in way and also satisfy panel stability requirement.

4.5.9 Where horizontal girders (or vertical webs) on the transverse bulkheads do not form part of a ring structure, they are to be arranged with substantial end brackets forming a buttress extending to the adjacent vertical web (or transverse). The shear and combined stresses in the buttress arrangement is to be specially examined.

4.6 Construction details

4.6.1 The members are to have adequate end fixity, lateral support and web stiffening, and the structure is to be arranged to minimize hard spots or other sources of stress concentration. Openings are to have well rounded corners and smooth edges and are to be located having regard to the stress distribution and buckling strength of the plate panel.

4.6.2 To maintain continuity of strength, substantial horizontal and vertical brackets are to be fitted to transverses or stringers at the ends of the cross ties. Horizontal brackets are to be aligned with the cross tie face plates, and vertical end brackets are to be aligned with the cross tie web.

4.6.3 In a ring system where the end bracket is integral with the webs of the members, and the face plate is carried continuously along the edges of the members and the bracket, the full area of the largest face plate is to be maintained upto the mid-point of the bracket and then gradually tapered to the smaller face plates. Butts in face plates are to be kept well clear of the toes of brackets.

4.6.4 The thickness of separate end brackets is generally to be not less than that of the thicker of the primary member webs being connected, but may be required to be locally increased at the toes. The bracket is to extend to adjacent tripping brackets, stiffeners or other support points. Bracket toes are to be well radiused. Where the bracket is attached to a corrugated bulkhead, the plating at the bracket toe is to be suitably reinforced.

4.6.5 Tripping brackets are generally to be fitted close to the toes of end brackets, in way of cross ties and generally at every fourth stiffener elsewhere. Arrangements should also be made to prevent tripping at the intersection with other primary members.

4.6.6 In way of cross ties and their end connections lightening holes are not to be cut in side and longitudinal bulkhead stringers. Lightening holes are also to be avoided on vertical webs on longitudinal bulkheads and in wing ballast tanks.

4.6.7 Holes cut in primary longitudinal members within 0.1D of deck and bottom are, in general to be reinforced. Where holes are cut in primary longitudinal members in areas of high stress and where primary members are of higher tensile steel, they are to be elliptical, or equivalent, to minimise stress concentration.

4.6.8 Longitudinals within the range of cargo tanks are not permitted to have closely spaced scallops except in way of ballast pipe suctions. Reinforcement in these areas will be specially considered. Small air and drain holes, cut-outs at erection butts and similar widely spaced openings are, in general not to be less than 200 [mm] clear of the toes of end brackets, intersections with primary supporting members and other areas of high stress. All openings are to be well rounded with smooth edges.

4.6.9 Where holes are cut for heating coils, the lower edge of the hole is to be not less than 100 [mm] from the inner bottom. Where large notches are cut in the transverses for the passage of longitudinal framing, adjacent to openings for heating coils, the notches for longitudinals are to be collared.

Section 5

Direct Strength Calculations

5.1 General

5.1.1 Direct strength calculations are required in cases where simplified formulations are not able to take into account special stress distributions, boundary conditions or structural arrangements with sufficient accuracy.

5.1.2 For those girder systems where such direct strength calculations are mentioned in the preceeding sections of this Chapter, scantlings obtained from simplified formulae may have to be increased based on the results obtained.

5.1.3 The computer programs used are to take into account the effects of bending, shear, axial and torsional deformations.

For deep girders, bulkhead panels, bracket zones etc. FEM or equivalent methods are to be applied. For systems consisting of slender girders, calculations may be based on beam theory.

The calculations are to reflect the structural response of 2 or 3-dimensional structure considered, with due attention to the boundary conditions.

5.1.4 The calculations are to be carried out using net thicknesses obtained after deduction of applicable corrosion additions specified in Pt.3, Ch.3.

5.2 Load cases and design loads

5.2.1 The calculations are to be carried out for the realistic condition which cause most severe loading on the various parts of cargo tank structures.

5.2.2 For transverse and longitudinal girders in the cargo region following conditions are to be considered:

- Sea-going conditions:
    - any cargo tank empty with adjacent cargo tanks full and the ship on full draught
    - any cargo tank filled with adjacent cargo tanks full and the ship at the minimum sea-going draught
    - all cargo tanks within a transverse section of the ship filled, with adjoining cargo tanks forward and aft empty and the ship at the minimum sea-going draught
    - In case of tanks of breadth > 0.6B, full tank with adjacent tanks empty, ship at the minimum sea-going draught and heeled at an angle of $\phi/2$ (ϕ = roll angle as per Pt.3, Ch.4, Sec.2).

- Harbour Conditions:

    - any cargo tank filled with adjacent tanks empty and the ship is at a draught of 0.35T

- all tanks in a section of the ship filled with adjacent tanks empty and the ship floating at a draught of 0.5T.

All load combinations based on the above are to be investigated for various types of longitudinal bulkhead arrangements.

5.2.3 For girders on transverse bulkheads, loading conditions involving alternate loading in centre tank and wing tanks are to be considered in addition to those mentioned in 5.2.2.

5.2.4 External sea pressures and internal tank pressure related to the specified draught and the filling height are to be considered, generally as per Pt.3, Ch.4.

For seagoing conditions realistic combinations of dynamic components of the external and internal pressures are to be considered. For harbour conditions only static pressures may be considered.

5.3 Allowable stresses

5.3.1 The values of allowable stresses given below are subject to satisfactory buckling strength as per Pt.3, Ch.3.

5.3.2 In the longitudinal girders, the combined longitudinal stress 'σ_{LC}', for the loads given in Sec.5.2 above, is not to exceed 230/k [N/mm^2].

$$\sigma_{LC} = \sigma_L + \sigma_g \quad [N/mm^2]$$

σ_L = hull girder bending stress based on total bending moment (M_s + M_w) as given in Pt.3, Ch.5 (hogging and sagging, as relevant).

σg = local bending stress in the girder under consideration [N/mm^2].

5.3.3 In transverse and vertical girders under loading given in Sec. 5.2 above, the following stress values are not to be exceeded

For seagoing conditions:	
bending or axial stress	σ = 160/k [N/mm^2]
shear stress	τ = 100/k [N/mm^2]
equivalent stress	$\sigma_e = \sqrt{(\sigma^2 + 3\tau^2)}$ = 180/k [N/mm^2]
For harbour conditions:	
bending or axial stress	σ = 180/k [N/mm^2]
shear stress	τ = 110/k [N/mm^2]
equivalent stress	σ_e = 200/k [N/mm^2]

Section 6

Pumping and Piping Systems

6.1 Cargo pump rooms

6.1.1 Cargo pump rooms are to be totally enclosed and are to have no direct communication with machinery spaces.

6.1.2 Pump rooms are to be situated within, or adjacent to, the cargo tanks area and are to be provided with ready means of access from the open deck.

6.1.3 In cargo pump rooms any drain pipes from steam or exhaust pipes or from the steam cylinders of the pumps are to terminate well above the level of the bilges.

6.1.4 Cargo pump rooms and other closed spaces which contain cargo handling equipment, and to which regular access is required during cargo handling are to be provided with permanent ventilation systems of the mechanical extraction type.

6.1.5 The ventilation system is to be capable of being operated from outside the compartment being ventilated, and a notice is to be fixed near the entrance stating that no person is to enter the space until the ventilation system has been in operation for at least 15 minutes.

6.1.6 The ventilation system is to be capable of 20 changes/hour. The number of air changes is to be based on the gross volume of the pump room or space.

6.1.7 The ventilation ducting is to be arranged to permit extraction from the vicinity of the pump room bilges, immediately above the transverse floor plates or bottom longitudinals. An emergency intake is also to be provided in the ducting at a height of 2 [m] above the pump room lower platform and is to be provided with a damper capable of being opened or closed from the weather deck and lower platform level. An arrangement involving a specific ratio of areas of upper emergency and lower main ventilation openings, which can be shown to result in at least the required number of air changes through the lower inlets, can be accepted without the use of dampers. When the lower inlets are sealed off owing to the flooding of the bilges, then at least 75 per cent of the required number of air changes is to be obtainable through the upper inlets. Means are to be provided to ensure the free flow of gases through the upper platform to the duct intakes.

6.1.8 The arrangements and materials of mechanical ventilator components are to be designed to prevent the risk of incendive sparking. Where non-metallic materials are used they are to have anti-static properties.

6.1.9 Renewable flame screens are to be provided in ventilation ducts, and ventilation intakes are to be so arranged as to minimise the possibility of re-cycling hazardous vapours from any ventilation discharge openings. Vent exits are to be arranged to discharge upwards.

6.1.10 Vent exits from pump rooms are to discharge at least 3 [m] above the deck and from the nearest air intakes or openings to accommodation and enclosed working spaces and from possible sources of ignition.

6.2 Piping systems for bilge, ballast, oil fuel etc.

6.2.1 There is to be no connection between piping systems in the cargo area and the piping systems in the remainder of the vessel, unless explicitly specified herein.

6.2.2 The oil fuel bunkering system is to be entirely separate from the cargo handling system.

6.2.3 The pumping arrangements in the machinery space and forward end of the ship are to comply with the requirements for general cargo ships, in so far as they are applicable.

6.2.4 Cargo pump rooms are to have a drainage system connected to pumps or bilge ejectors. The cargo pumps may be used for this purpose provided each bilge suction pipe is fitted with a screw-down non-return valve and an additional valve/cock is fitted to the pipe connection between the pump and the non-return valve. Pump room suctions are not to enter the engine room.

6.2.5 Cofferdams, which are required to be provided at the fore and aft ends of the cargo spaces, are to be fitted with suitable drainage arrangements, generally, in accordance with following:

6.2.5.1 Where deep cofferdams can be filled up with water ballast, a ballast pump in the main engine room may be used for emptying the after cofferdam. Where fitted, a ballast pump in a forward pump room may be used for draining the forward cofferdam. In each case, the suctions are to be led direct to the pump and not to a pipe system.

6.2.5.2 Where intended to be dry compartments, after cofferdam adjacent to the pump room may be drained as provided in 6.2.4. Forward cofferdam may be drained by a bilge/ballast pump in a forward pump room. Alternatively, cofferdams may be drained by bilge ejectors.

6.2.6 Cofferdams are to have no direct connections to cargo tanks or cargo lines.

6.2.7 Ballast tanks and void spaces within the cargo area are not to be connected to cargo pumps or have any connections to the cargo system. A separate ballast/bilge pump is to be provided for dealing with the contents of these spaces. This pump is to be located in the cargo pump room or other suitable space within the cargo area.

Consideration will be given to connecting double bottom and/or wing tanks, which are in the cargo area, to pumps in the machinery spaces where the tanks are completely separated from the cargo tanks by cofferdams, heating ducts, or containment spaces, etc.

The forepeak tank can be ballasted with the system serving ballast tanks within the cargo area, provided:

- the forepeak tank is considered as hazardous area;

- the vent pipe openings are located on open deck at an appropriate distance from sources of ignition. In this respect, the hazardous zones distances are to be defined in accordance to IEC 60092-502: Electrical installations in ships - Tankers – Special features;

- means are provided, on the open deck, to allow measurement of flammable gas concentrations within the forepeak tank by a suitable portable instrument;

- the sounding arrangement to the forepeak tank is direct from open deck;

- the access to the forepeak tank is direct from open deck. Alternatively, indirect access from the open deck to the forepeak tank through an enclosed space may be accepted provided that:

    a) In case the enclosed space is separated from the cargo tanks by cofferdams, the access is through a gas tight bolted manhole located in the enclosed space and a warning sign is to be provided at the manhole stating that the forepeak tank may only be opened after:

        i) it has been proven to be gas free; or
        ii) any electrical equipment which is not certified safe in the enclosed space is isolated.

    b) In case the enclosed space has a common boundary with the cargo tanks and is therefore a hazardous area, the enclosed space can be well ventilated.

The hazardous area classification for above is in accordance to IEC 60092-502: Electrical installations in ships - Tankers - Special features.

6.2.8 Ballast piping is not to pass through cargo tanks as far as possible and is not to be connected to cargo oil piping. Provision may, however, be made for emergency discharge of water ballast by means of a portable spool connection to a cargo oil pump and where this is arranged, a non-return valve is to be fitted in the ballast suction to the cargo oil pump. The portable spool piece is to be mounted in a conspicuous position in the pump room and a permanent notice restricting its use is to be prominently displayed adjacent to it. Shut-off valves shall be provided to shut-off the cargo and ballast lines before the spool piece is removed.

Ballast piping passing through cargo tanks and cargo oil pipes passing through segregated ballast tanks, as permitted by MARPOL Annex I Reg. 19, are to be of heavy gauge steel of minimum wall thickness according to the table hereunder with welded or heavy flanged joints the number of which is to be kept to a minimum. Only expansion bends (not glands) are permitted in these lines within cargo tanks for serving the ballast tanks and within the ballast tanks for serving the cargo tanks.

Nominal diameter [mm]	**Minimum wall thickness of carbon steel pipes mm]**
50	6.3
100	8.6
125	9.5
150	11.0
200 and above	12.5

Thickness for intermediate sizes may be calculated by interpolation.

6.2.9 Deep cofferdams at the fore and aft ends of the cargo spaces and other tanks or cofferdams within the range of the cargo tanks, which are not intended for cargo, are to be provided with air and sounding pipes led to the open deck. The air pipes are to be fitted with wire gauge diaphragms at their outlets.

6.2.10 So far as practicable, the air and sounding pipes required by 6.2.9 are not to pass through cargo tanks. Where this cannot be avoided e.g. on oil tankers of deadweight less than 5000 tonnes, where wing ballast tanks or spaces need not be provided, the sounding and air pipes may pass through the cargo tanks. However, the pipes are to be of steel having a wall thickness of not less than 12.5 [mm] and they are to be in continuous lengths or with welded joints.

6.2.11 The requirements for integrated cargo and ballast systems are given in Sec.7.6.

6.3 Steam connection to cargo tanks

6.3.1 Where steaming out and/or fire extinguishing connections are provided for cargo tanks or cargo pipe lines, they are to be fitted with valves of the screw-down non-return type. The main supply to these connections is to be fitted with a master valve placed in a readily accessible position clear of the cargo tanks.

6.4 Equipment in dangerous spaces

6.4.1 Oil engines, or, any other equipment which could constitute a possible source of ignition, are not to be situated within cargo tanks, pump rooms, cofferdams or other spaces liable to contain explosive vapours or in spaces immediately adjacent to cargo oil or slop tanks. The temperature of steam or other fluid, in pipes (or heating coils) in these spaces is not to exceed 220°C.

6.4.2 Measures are to be taken to prevent explosions in cargo pump rooms. Cargo pumps, ballast pumps and stripping pumps, installed in cargo pump rooms and driven by shafts passing through pump room bulkheads are to be fitted with temperature sensing devices for bulkhead shaft glands, bearing, and pump casings. Alarms are to be initiated in the cargo control room or the pump control station.

6.4.3 Lighting in cargo pump room is to be interlocked with ventilation such that ventilation shall be in operation when switching on the lighting. Failure of the ventilation system is not to cause the lighting to go out. Emergency lighting if fitted is not to be interlocked.

6.4.4 A system for continuously monitoring the concentration of hydrocarbon gases is to be fitted. Sequential sampling is acceptable as long as it is dedicated for the pump room only, including exhaust ducts and the sampling time is reasonably short. Sampling points or detector heads shall be located in suitable positions e.g. exhaust ventilation ducts and lower parts of pump rooms above floor plates, in order that potentially dangerous leakages are readily detected. The system is to raise an alarm if the concentration of hydrocarbon reaches a pre-set level which shall not be higher than 10 percent of the lower flammable limit (LFL). Audible and visual signals are to be provided in the pump room, engine control room, cargo control room and on the navigation bridge.

Gas analysing units with non-explosion proof measuring equipment may be located in areas outside cargo areas, e.g. in cargo control room, navigation bridge or engine room when mounted on the forward bulkhead provided the following requirements are observed:

a) Sampling lines are not to run through gas safe spaces, except where permitted under (e).

b) The gas sampling pipes are to be equipped with flame arresters. Sample gas is to be led to the atmosphere with outlets arranged in a safe location.

c) Bulkhead penetrations of sample pipes between safe and dangerous areas are to be of approved type and have same fire integrity as the division penetrated. A manual isolating valve is to be fitted in each of the sampling lines at the bulkhead on the gas safe side.

d) The gas detection equipment including sample piping, sample pumps, solenoids, analysing units etc. are to be located in a reasonably gas tight enclosure (e.g. a fully enclosed steel cabinet with a gasketed door) being monitored by its own sampling point. At gas concentrations above 30 per cent LFL inside the enclosure the entire gas analysing unit is to be automatically shut down.

e) Where the enclosure cannot be arranged directly on the bulkhead, sample pipes are to be of steel or other equivalent material and without detachable connections, except for the connection points for isolating valves at the bulkhead and analysing units and are to be routed on their shortest ways.

The above requirements are also applicable to gas analysing units of the sampling type located outside gas dangerous zones and fitted on board gas carriers or chemical tankers.

6.4.5 All pump rooms are to be provided with bilge level monitoring devices together with audio-visual alarms in the wheel house, pump control station and other appropriate locations.

IR6.4.5 The above requirements 6.4.2 to 6.4.5 are only applicable to the pump-rooms where pumps for cargo, such as cargo pumps, stripping pumps, pumps for slop tanks, pumps for COW or similar pumps are provided. Pump rooms intended solely for ballast transfer and/or fuel oil transfer need not comply with 6.4.2 to 6.4.5 above.

6.5 Non-sparking fans

6.5.1 A fan is considered as non-sparking if in either normal or abnormal conditions it is unlikely to produce sparks.

6.5.2 The air gap between the impeller and the casing is to be not less than 0.1 of the shaft diameter in way of the impeller bearing but not less than 2 [mm] and in any case not more than 13 [mm].

6.5.3 Protection screens of not more than 13 [mm] square mesh are to be fitted in the inlet and outlet ventilation openings on the open deck to prevent the entrance of objects into the fan housing.

6.5.4 The impeller and the housing in way of the impeller are to be made of alloys which are approved as being spark proof by appropriate test.

6.5.5 Electrostatic charges both in the rotating body and the casing are to be prevented by the use of antistatic materials. Furthermore, the installation on board of the ventilation units is to be such as to ensure the safe bonding to the hull of the units themselves.

6.5.6 Tests may not be required for fans having the following combinations:

a) impellers and/or housings of nonmetallic material, due regard being paid to the elimination of static electricity,

b) impellers and housings of non-ferrous materials,

c) impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness on non-ferrous materials is fitted in way of the impeller,

d) any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 [mm] tip design clearance.

6.5.7 The following impellers and housings are considered as sparking and are not permitted:

a) impellers of an aluminium alloy or magnesium alloy and a ferrous housing, regardless of tip clearance,

b) housing made of an aluminium alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance,

c) any combination of ferrous impeller and housing with less than 13 [mm] design tip clearance.

6.5.8 Type tests on the finished product are to be carried out in accordance with the requirements of the 'Rules and Regulations for the Construction and Classification of Steel Ships' or an equivalent national or international standard.

6.6 Earthing and bonding of cargo tanks and piping systems for cargo of flash point not exceeding 60°C

6.6.1 Independent cargo tanks and cargo piping systems intended for cargo with flash point not exceeding 60°C are to be connected to the hull of the ship so that resistance between them and the hull is less than 10^6 [ohm].

6.6.2 Bonding straps are required for cargo tanks/piping systems which are not permanently connected to the hull of the ship, e.g.

a) Independent cargo tanks;

b) Cargo tanks/piping systems which are electrically separated from the hull of the ship;

c) Pipe connections arranged for the removal of spool pieces.

d) Wafer-style valves with non-conductive (e.g. PTFE) gaskets or seals.

6.6.3 Where bonding straps are required, they are to be:

a) Clearly visible so that any shortcomings can be clearly detected;

b) Designed and sited so that they are protected against mechanical damage and that they are not affected by high resistivity contamination e.g. corrosive products or paint;

c) Easy to install and replace.

Section 7

Cargo Handling Systems

7.1 General

7.1.1 A complete system of piping and pumps is to be fitted for dealing with the cargo.

7.1.2 Standby means for pumping out each cargo tank are to be provided.

7.1.3 Where cargo tanks are provided with single deep well pumps, or submerged pumps, it will be necessary to provide alternative means for emptying the tanks in the event of failure of a pump. Portable submersible pumps may be provided on board for this purpose, but the arrangements are to be such that a portable pump could be safely introduced in to a full or part full tank. Details of the arrangements are to be submitted for approval.

7.1.4 Cargo tank access hatches and all other openings to cargo tanks, such as ullage and tank cleaning openings, sighting ports and restricted sounding devices, are to be located on the weather deck and are not to be arranged in enclosed compartments.

7.2 Cargo pumps

7.2.1 Cargo oil pumps are to be designed so as to minimise the risk of sparking and oil leakage at the stuffing box.

7.2.2 Where cargo pumps are driven by shafting which passes through a pump room bulkhead, shafting is to be provided with flexible couplings and gastight stuffing boxes are to be fitted to the shaft at the pump room bulkhead. The glands are to be efficiently lubricated from outside the pumproom and constructed so as to reduce the risk of overheating. The bulkhead shaft glands, bearings and pump casings are to be provided with temperature sensing devices. Alarms are to be initiated in the cargo control room or the pump control station.

Parts, which may come in contact, if the seals are misaligned or bearings are damaged, are to be of materials which will not spark. Where bellows are incorporated in the design, these are to be hydraulically tested to 3.4 bar before fitting.

7.2.3 A stop valve and a relief valve of adequate capacity are to be fitted on the delivery side of each pump. Relief valves are to be fitted in close- circuit, i.e. discharging to the suction side of the pumps. Relief valve may be omitted in case of centrifugal pumps, which are so designed that the discharge pressure cannot exceed the design pressure.

7.2.4 A pressure gauge is to be fitted on the delivery side of each pump. Where the pump is driven by a prime mover, which is installed in a space other than the pump room, an additional pressure gauge is to be fitted at a suitable position visible from the controlling position of the prime mover.

7.2.5 Where cargo pumps are driven by hydraulic motors which are located inside cargo tanks, the design is to be such that the contamination of the operating media and cargo oil cannot take place under normal operating conditions.

7.2.6 Means are to be provided for stopping the cargo oil pumps from a position outside the pump rooms, as well as at the pumps.

7.2.7 In general, cargo oil pumps are to be driven by steam where the prime movers are installed in the pump rooms. Where the prime movers are not driven by steam, details are to be submitted for special approval.

7.3 Cargo piping systems

7.3.1 The complete cargo piping system is to be located within the cargo tank area.

7.3.2 Expansion joints of approved type or bends are to be provided, where necessary, in the cargo pipe lines.

7.3.3 Means for drainage of cargo lines are to be provided. Drain lines may be led to a cargo tank or to a separate tank for this purpose.

7.3.4 The cargo piping system is not to have any connection to permanent ballast tanks.

7.3.5 Filling lines to cargo tanks are to be so arranged that the formation of static electricity is reduced. When cargo is loaded directly into tanks, the loading pipes are to be led as low as practicable in the tank.

7.3.6 Terminal pipes, valves and other fittings in the cargo loading and discharge lines to which shore installation hoses are directly connected, are to be of steel or approved ductile material. They are to be strongly supported. A manually operated shut-off valve is to be fitted to each shore loading/discharging connection.

7.3.7 Where a cargo hose connection is arranged outside the cargo area, the pipe leading to such connection is to be provided with means of segregation such as a spectacle flange or removable spool piece or equivalent (see MSC Circ.474) located within cargo area. The space within 3 [m] of the cargo hose connection flange is to be considered as a dangerous area with regard to electrical or incendiary equipment.

7.3.8 Isolation of piping systems which serve tanks containing incompatible cargoes are to be made by means of removable pipe lengths and blank flanges. Isolating shut off valves, single or double, or spectacle flanges are not acceptable as equivalent arrangement.

7.3.9 Cargo piping is not to be led through any tank containing a cargo which is incompatible with that contained in the tank served by such piping, unless it is encased in a pipe tunnel.

7.3.10 Where cargo suction and/or filling lines are led through cargo tanks, or through other spaces situated below the weather deck, the connection to each tank is to be provided with a valve situated inside the tank, and capable of being operated from the deck. In the case of cargo tanks which are located adjacent to below-deck pump rooms, or pipe tunnels, the deck operated valve may be located in these spaces at the bulkhead. In any case, not less than two isolating shut off valves are to be provided in the pipelines between the tanks and cargo pumps.

7.4 Remote control of valves

7.4.1 Valves on deck and in pump rooms which are provided with remote control, are, in general, to be arranged for local manual operation independent of the remote operating mechanism.

7.4.2 Where the valves and their actuators are located inside the cargo tanks, two separate suctions are to be provided in each tank, or alternative means of emptying the tank, in the event of a defective actuator, are to be provided.

7.4.3 All actuators are to be of a type which will prevent the valves from opening inadvertently in the event of the loss of pressure in the operating medium. Indication is to be provided at the remote control station showing whether the valve is open or shut.

7.4.4 Compressed air is not to be used for operating actuators inside cargo tanks. The actuator operating medium in hydraulic systems is to have a flash point of 60°C or above (Closed Cup Test) and is to be compatible with the intended cargoes.

7.4.5 The design of the actuator is to be such that contamination of the operating medium with cargo liquid cannot take place under normal operating conditions.

7.4.6 Where the operating medium is oil or other fluid, the supply tank is to be located as high as practicable above the level of the top of the cargo tanks, and all actuator supply lines are to enter the tanks through the highest part of the tanks. Furthermore the supply tank is to be of the closed type with an air pipe led to a safe space on the open deck and fitted with a flameproof wire gauge diaphragm at it's open end. This tank is also to be fitted with a high and low level audible and visual alarm. The requirements of this paragraph need not be complied with if the actuators and piping are located external to the cargo tanks.

7.4.7 It is recommended that for remote control valves not arranged for manual operation, emergency means be provided for operating the valve actuators in the event of damage to the main hydraulic circuits on deck. In the case of valves located inside cargo tanks, this could be achieved by ensuring that the supply lines to actuators are led vertically inside the tank from deck, and that connections with necessary isolating valves, are provided on deck for coupling to a portable pump carried on board.

7.5 Cargo handling controls

7.5.1 Electrical measuring, monitoring control and communication circuits located in dangerous spaces are to be intrinsically safe.

7.5.2 The handling controls and instruments are to be arranged for safe and easy operation. They may be grouped at a number of control stations or at one main control station.

7.5.3 A satisfactory means of communication is to be provided between cargo handling stations, open deck, the bridge and the machinery spaces.

7.5.4 The cargo handling controls and instrumentation are, so far as possible, to be separate from the propulsion and auxiliary machinery controls and instrumentation.

7.6 Integrated cargo and ballast systems on tankers

7.6.1 The following requirements apply to integrated cargo and ballast systems meaning any integrated hydraulic and/or electric system used to drive both cargo and ballast pumps (including active control and safety systems, but excluding passive components, e.g. piping).

7.6.2 Adequate measures are to be taken to prevent cargo and ballast pumps becoming inoperative simultaneously due to a single failure in the integrated cargo and ballast system, including its control and safety systems in order to ensure that these systems are available for use even in emergency condition whilst at sea

7.6.3 The following features are to be ensured:

- The emergency stop circuits of the cargo and ballast systems are to be independent from the circuits for the control systems. A single failure in the control system circuits or the emergency stop circuits are not to render the integrated cargo and ballast system inoperative;

- Manual emergency stops of the cargo pumps are to be arranged in such a way that they do not de-activate the power pack affecting the operation of the ballast pump;

- The control systems are to be provided with backup power supply, which may be served by a duplicate power supply from the main switch board. The failure of any power supply is to initiate audible and visual alarm at each location where the control panel is fitted;

- In the event of failure of the automatic or remote control systems, a secondary means of control is to be made available for the operation of the integrated cargo and ballast system. This is to be achieved by manual overriding and/or redundant arrangements within the control systems.

Section 8

Gas Freeing and Venting of Cargo Tank

8.1 Cargo tank venting

8.1.1 Provision is to be made for the gas freeing of the cargo oil tanks when the cargo has been discharged and for the ventilation and gas freeing of all compartments adjacent to cargo oil tanks.

The venting systems of cargo tanks are to be entirely distinct from the air pipes of the other compartments of the ship. The arrangements and position of openings in the cargo tank deck from which emission of flammable vapours can occur is to be such as to minimize the possibility of flammable vapours being admitted to enclosed spaces containing a source of ignition, or collecting in the vicinity of deck machinery and equipment which may constitute an ignition hazard.

8.1.2 Every oil tanker is to be provided with at least two portable O_2 analysers and two portable gas detectors capable of measuring flammable vapour concentrations in air.

8.1.3 There is to be no connection between the gas freeing system and the ventilation system for cargo pump room.

8.1.4 Each cargo tank is to be fitted with venting arrangements which will limit the pressure or vacuum in the tanks. Venting arrangements are to be designed to provide:

a) pressure/vacuum release of small volumes of vapour/air mixtures flowing during a normal voyage, and

b) venting of large volumes of vapour/air mixtures during cargo handling and gas freeing operations,

c) a secondary means of allowing full flow relief of vapour, air or inert gas mixtures to prevent over-pressure or under-pressure in the event of failure of the arrangements provided for (b) above. Alternatively, pressure sensors may be fitted in each tank protected by arrangements required by (b) above, with a monitoring system in the ship's cargo control room or the position from which cargo operations are normally carried out. Such monitoring equipment is to also provide an alarm facility which is activated by detection of over-pressure or under-pressure conditions within a tank.

A P/V breaker fitted on the IG main may be accepted as secondary means of relief where the cargo is homogenous or for multiple cargoes where the vapours are compatible and do not require isolation. Where the venting arrangements are of the free flow type and the masthead isolation valve is closed for the unloading condition, the IG system will serve as the primary under-pressure protection with the P/V breaker serving as the secondary means.

In-advertent closure or mechanical failure of the isolation valves required by 8.1.7 and 11.6.15 need not be considered in establishing the secondary means where the cargo is homogenous or for multiple cargoes where the vapours are compatible and do not require isolation since:

- the valves are operated under the control of the ship’s responsible officer and the clear visual indication of the operational status of the valve is to be provided as required by 8.1.7 and

- the possibility of mechanical failure of the valves is remote due to their simplicity.

For ships that apply pressure sensors in each tank as an alternative secondary means of relief as per (c) above, the setting of the over-pressure alarm is to be above the pressure setting of the P/V-valve and the setting of the under-pressure alarm is to be below the vacuum setting of the P/V-valve. The alarm settings are to be within the design pressures of the cargo tanks. The settings are to be fixed and not arranged for blocking or adjustment in operation*.

* An exception is permitted for ships that carry different types of cargo and use P/V-valves with different settings, one setting for each type of cargo. The settings may be adjusted to account for the different types of cargo.

8.1.5 Provision is to be made to ensure that the liquid head in any tank does not exceed the test head of the tank; suitable high level alarms, together with gauging devices and tank filling procedures, may be accepted for this purpose.

8.1.6 The pressure/vacuum system and venting system for the cargo tanks may be separate or combined and may be connected to an inert gas system. Due regard is given to the cargo segregation requirements.

8.1.7 The vent and/or pressure/vacuum valve stand pipes are to be connected to the highest part of each tank and where combined systems are adopted, a means of isolation is to be provided between each tank and common main. Where stop valves are fitted, these are to be provided with locking arrangements and which shall be under the control of responsible ship's officer. There is to be a clear visual indication of the operational status of the valves or other acceptable means. The means of isolation are to be such that tank breathing is maintained when the tank is isolated. Where tanks have been isolated, it is to be ensured that relevant isolating valves are opened before cargo loading or ballasting or discharging of those tanks is commenced.

If cargo loading and ballasting or discharging of a cargo tank or cargo tank group is intended, which is isolated from the common venting system, that cargo tank or cargo tank group is to be fitted with a means for over- pressure or under-pressure protection required by 8.1.5.

8.1.8 Pressure/vacuum valves are to be set at a positive pressure of not more than 0.2 bar above atmospheric and a negative pressure of not more than 0.07 bar below atmospheric unless the tank scantlings are specially considered.

8.1.9 In no case are shut-off valves to be fitted either above or in the pipe leading to a pressure/vacuum valve. However, bypass valves may be fitted or provision may be made to enable the tank pressure/vacuum valves to be held in an open position. The arrangements are to be such that clear indication is given when the bypass valve is open or the pressure/vacuum valve is secured in the open position. Means are to be provided to check the functioning of the pressure/vacuum valves.

8.1.10 The area of the venting system used during cargo loading is to be based on the maximum design loading rate and a gas evolution factor of 1.25.

8.1.11 Suitable drainage arrangements are to be provided in the vapour lines. The venting arrangements are to be self draining to the cargo tanks under all normal condition of trim and list of the ship. Where it may not be possible to provide self draining lines, permanent arrangements are to be provided to drain the vent lines to a cargo tank.

8.1.12 The venting system is to be provided with devices to prevent the passage of flame into the cargo tanks. The design, testing and locating of these devices are to comply with the requirements approved by the National Statutory Authority*. Ullage openings are not to be used for pressure equalization. They are to be provided with self-closing and tightly sealing covers. Flame arresters and screens are not permitted in these openings.

Ullage openings do not include cargo tank openings that are fitted with standpipe arrangements with its own manually operated shutoff valves.

Examples include the common 25 to 50 [mm] diameter standpipe arrangements that are used for sampling, monitoring or measuring of ullage/temperature/interface, oxygen, liquid and hand dipping in the cargo tank.

** Refer to MSC/Circ.677 as amended by MSC / Circ.1009 on Revised standards for the design, testing and locating of devices to prevent the passage of flame into cargo tanks in tankers and to MSC/Circ.450/Rev.1 on Revised factors to be taken into consideration when designing cargo tank venting and gas-freeing arrangements.*

8.1.13 Vent outlets and pressure/vacuum valve outlets, if used during loading, are to be arranged to discharge the vapour in an upward vertical direction. All outlets are to be arranged to prevent the entrance of water into the cargo tanks.

8.1.14 Openings for pressure release required by 8.1.4(a) are to :

a) have as great a height as is practicable above the cargo tank deck to obtain maximum dispersal of flammable vapours but in no case less than 2 [m] above the cargo tank deck, and

b) be arranged at the furthest distance practicable but not less than 5 [m] from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery and equipment which may constitute an ignition hazard.

IR-b) Electrical equipment fitted in compliance with IEC Publication 60092 – "Electrical installations in ships – Part 502 : Tankers – Special features" is not considered a source of ignition or ignition hazard (refer Pt 4, Ch. 8, Clause 12.9.10.1 for area classification for electrical equipment installation).

The height requirements given in 8.1.14 and 8.1.15 and the requirements for devices to prevent the passage of flame are not applicable to the P/V breaker provided the settings are above those of the venting arrangements given in 8.1.4 (a) and (b).

8.1.15 Vent outlets for cargo loading, discharging and ballasting required by 8.1.4(b) are to :

a) permit the free flow of vapour mixtures or alternatively, permit the throttling of the discharge of the vapour mixtures to achieve a velocity of not less than 30 metres/second.

b) be so arranged that the vapour mixture is discharged vertically upwards.

c) where the method is by free flow of vapour mixtures, be such that the outlet is not less than 6 [m] above the cargo tank deck or fore and aft gangway if situated within 4 [m] of gangway and located not less than 10 [m] measured horizontally from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery, which may include anchor windlass and chain locker openings and equipment which may constitute an ignition hazard.

IR-c) Electrical equipment fitted in compliance with IEC Publication 60092 – "Electrical installations in ships – Part 502 : Tankers – Special features" is not considered a source of ignition or ignition hazard (refer Pt 4, Ch. 8, Clause 12.9.10.2 for area classification for electrical equipment installation).

d) where the method is by high velocity discharge, be located at a height not less than 2 [m] above the cargo tank deck and not less than 10 [m] measured horizontally from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery, which may include anchor windlass and chain locker openings and equipment which may constitute an ignition hazard. These outlets are to be provided with high velocity devices of an approved type.

e) the Master is to be provided with information regarding the maximum permissible loading rate for each cargo tank and in case of combined venting systems, for each group of cargo tanks.

8.1.16 The arrangements for the venting of all vapours displaced from the cargo tanks loading and ballasting are to comply with this section and are to consist of either one or more mast risers, or a number of high velocity vents. The inert gas supply mains may be used for such venting.

8.2 Cargo tank purging and/or gas freeing

8.2.1 Arrangements for purging/and or gas freeing are to be such as to minimise the hazards due to the dispersal of flammable vapours in the atmosphere and to flammable mixtures in cargo tank.

8.2.2 When the ship is provided with an inert gas system the cargo tanks are first to be purged until the concentration of hydrocarbon vapours has been reduced to less than 2 per cent by volume. Thereafter gas freeing may take place at the cargo tank deck level.

8.2.3 The arrangements for inerting, purging or gas-freeing of empty tanks as required in 8.2.2 are to be to the satisfaction of IRS and are to be such that the accumulation of hydrocarbon vapours in pockets formed by the internal structural members in a tank is minimized and that:

.1 on individual cargo tanks, the gas outlet pipe, if fitted, shall be positioned as far as practicable from the inert gas/air inlet and in accordance with 8.1 and Pt.6 Ch.3, 5.6. The inlet of such outlet pipes may be located either at deck level or at not more than 1 m above the bottom of the tank;

.2 the cross-sectional area of such gas outlet pipe referred to in 8.2.3.1 is to be such that an exit velocity of at least 20 [m/s] can be maintained when any three tanks are being simultaneously supplied with inert gas. Their outlets shall extend not less than 2 m above deck level; and

.3 each gas outlet referred to in paragraph 8.2.3.2 is to be fitted with suitable blanking arrangements.

.4 if a connection is fitted between the inert gas supply mains and the cargo piping system, arrangements are to be made to ensure an effective isolation having regard to the large pressure difference which may exist between the systems. This is to consist of two shut-off valves with an arrangement to vent the space between the valves in a safe manner or an arrangement consisting of a spool-piece with associated blanks. The valve separating the inert gas supply main from the cargo main and which is on the cargo main side is to be a non-return valve with a positive means of closure.

IR.4 as a guide, the effective isolation required by .4 above may be achieved by the two arrangements shown in Fig. 8.2.3.4.

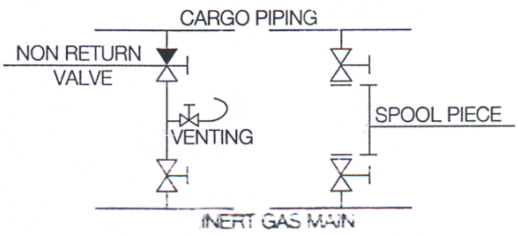

Fig.8.2.3.4

8.2.4 One or more pressure-vacuum breaking devices are to be provided to prevent the cargo tanks from being subject to:

a) a positive pressure in excess of the test pressure of the cargo tank if the cargo were to be loaded at the maximum rated capacity and all other outlets were left shut; and

b) a negative pressure in excess of 700 [mm] water gauge if cargo were to be discharged at the maximum rated capacity of the cargo pumps and the inert gas blowers were to fail.

Such devices are to be installed on the inert gas main unless they are installed in the venting system or on individual cargo tanks.

8.2.5 When the ship is not provided with an inert gas system, the operation is to be such that the flammable vapour is initially discharged either:

a) through the vent outlets as specified in 8.1.15; or

b) through outlets at least 2 [m] above the cargo tank deck level with a vertical efflux velocity of at least 30 metres/second maintained during gas freeing operation; or

c) through outlets at least 2 [m] above the cargo tank deck level with a vertical efflux velocity of at least 20 metres/second and which are protected by suitable devices to prevent the passage of flame.

8.2.6 When the flammable vapour concentration at the outlet has been reduced to 30 per cent of the lower flammable limit, gas freeing may thereafter be continued at the cargo tank deck level.

8.2.7 At least two oxygen sensors are to be positioned at appropriate locations in the space or spaces containing the inert gas system. Also refer Pt. 6, Ch. 8, Sec.15, Cl.15.2.2.4.5.4, regarding measurements in inert atmosphere. Suitable means are to be provided for the calibration of such instruments.

8.3 Inerting, ventilation and gas measurement detection of double hull and double bottom spaces

8.3.1 Double hull and double bottom spaces are to be fitted with suitable connections for the supply of air.

8.3.2 On tankers required to be fitted with inert gas systems:

a) double hull spaces are to be fitted with suitable connections for the supply of inert gas;
b) where hull spaces are connected to a permanently fitted inert gas distribution system, means are to be provided to prevent hydrocarbon gases from the cargo tanks entering the double hull spaces through the system;
c) where such spaces are not permanently connected to an inert gas distribution system, appropriate means are to be provided to allow connection to the inert gas main.

8.3.3 At least two suitable portable instruments for measuring oxygen and flammable vapour concentrations are to be provided. In selecting these instruments, due attention shall be given to their use in combination with the fixed gas-sampling-line systems referred to in paragraph 8.3.4.

8.3.4 Where the atmosphere in double hull spaces cannot be reliably measured using flexible gas sampling hoses, such spaces are to be fitted with permanent gas sampling lines. The configuration of such line systems are to be adapted to the design of such spaces.

8.3.5 The materials of construction and the dimensions of gas sampling lines are to be such as to prevent restriction. Where plastic materials are used, they should be electrically conductive.

8.3.6 Arrangements for fixed hydrocarbon gas detection systems in double-hull and double-bottom spaces of oil tankers

8.3.6.1 In addition to the requirements in 8.3.3 to 8.3.5 above, oil tankers of 20,000 tonnes deadweight and above, constructed on or after 1 January 2012, are to be provided with a fixed hydrocarbon gas detection system complying with Pt.6, Ch.8 for measuring hydrocarbon gas concentrations in all ballast tanks and void spaces of double-hull and double-bottom spaces adjacent to the cargo tanks, including the forepeak tank and any other tanks and spaces under the bulkhead deck adjacent to cargo tanks. The terms used in this requirement are to be interpreted as follows:

a) *"cargo tanks"* in the phrase *"spaces adjacent to the cargo tanks"* includes slop tanks except those arranged for the storage of oily water only.
b) *"spaces"* in the phrase *"spaces under the bulkhead deck adjacent to cargo tanks"* includes dry compartments such as ballast pump-rooms and bow thruster rooms and any tanks such as freshwater tanks, but excludes fuel oil tanks.
c) *"adjacent"* in the phrase *"adjacent to the cargo tanks"* includes ballast tanks, void spaces, other tanks or compartments located below the bulkhead deck located adjacent to cargo tanks and includes any spaces or tanks located below the bulkhead deck which form a cruciform (corner to corner) contact with the cargo tanks.

8.3.6.2 Oil tankers provided with constant operative inerting systems for such spaces need not be equipped with fixed hydrocarbon gas detection equipment.

8.3.6.3 Notwithstanding the above, cargo pump-rooms complying with the provisions of 6.4.2 to 6.4.5 and IR6.4.5 need not comply with the requirements of this paragraph (i.e. 8.3.6).

Section 9

Cargo Tank Level Measurement

9.1 General

9.1.1 Following types of sounding devices may be accepted:

a) Open type : A method which makes use of an opening in the tank and directly exposes the operator to the cargo or it's vapours. Examples of this type are ullage openings and gauge hatches, etc. (Also refer 7.1.4).

b) Restricted type : A device which penetrates the tank and which, when in use, permits a limited quantity of cargo vapour or liquid to be expelled to the atmosphere. Examples of this type are sounding pipe, rotary tube, etc. (Also refer 7.1.4).

c) Closed type : A device which penetrates the tank, but which is a part of the closed system which keeps the cargo completely sealed off from the atmosphere. The examples of this kind are sight glasses, pressure cells, float-type, radar type systems etc.

(Also refer Pt.6, Ch.2, 1.5.5.3.3).

9.1.2 Each cargo tank is to be fitted with at least one level gauging device. Where only one liquid level measuring device is fitted, it is to be arranged so that any necessary maintenance can be carried out while the cargo tank is in service.

9.1.3 If a closed measuring device is not mounted directly on the tank, it is to be provided with shut off valves situated as close as possible to the tank.

Section 10

Cargo Heating Arrangements

10.1 General

10.1.1 Following requirements are to be complied with for vessels fitted with heating arrangements for cargoes.

10.1.2 Spectacle flanges or spool pieces are to be provided in the heating medium supply and return pipes to the cargo heating system, in a suitable position in the cargo area, so that the lines can be blanked off in circumstances where the cargo does not require to be heated or where the heating coils have been removed from the tank. Alternatively, blanking arrangements may be provided for each tank heating circuit.

10.1.3 The heating medium is to be compatible with the cargoes to be heated. Where a combustible liquid is used as the heating medium it is to have a flash point of 60°C or above (Closed Cup Test). In general the temperature of the heating medium is not to exceed 220°C.

10.1.4 The heating medium supply and return lines are not to penetrate the cargo tank plating, other than at the top of the tank, and the main supply lines are to be run above the weather deck.

10.1.5 Isolating shut-off valves or cocks are to be provided at the inlet and outlet connections of each tank, and means are to be provided for regulating the flow.

10.1.6 Where steam or water is employed in the heating circuits, the returns are to be led to an observation tank which is to be in a well ventilated and well lighted part of the machinery space remote from the boilers.

10.1.7 Where a thermal oil is employed in the heating circuits, the arrangements will be specially considered.

10.1.8 In any heating system, a higher pressure is to be maintained within the heating circuit than the maximum pressure head which can be exerted by the contents of the cargo tank on the circuit. Alternatively, when the heating circuit is not in use, it may be drained and blanked.

10.1.9 Means are to be provided for measuring the cargo temperature.

Section 11

Inert Gas Systems

11.1 General

11.1.1 The applicability of inert gas systems for tankers is given in Pt.6, Ch.2, 1.5.5.

11.1.2 Inert gas systems on tankers are to be provided in accordance with the requirements in Pt.6, Ch.8, Sec.15.

Section 12

Ships for Carriage of Oil or Dry Cargo in Bulk

12.1 General

12.1.1 Ships intended to carry either oil in bulk with flash point not exceeding 60°C (closed cup test) or alternatively dry bulk cargo are to comply with the additional requirements of this section.

12.1.2 Relevant requirements for bulk carriers and ore carriers given in Pt.5, Ch.1 are also to be complied with, as applicable.

12.1.3 Dry cargoes and oil (with flash point below 60°C) are not be carried simultaneously, except for oil retained in protected slop tanks when the ship is carrying dry cargoes. Prior to employing the ship for the carriage of dry cargoes, the entire cargo area is to be cleaned, gas freed, inerted and isolated in accordance with the requirements of the National or Port Authorities.

12.1.4 Attention is drawn to the requirements of Pt.6, Ch.2, 1.5.4.2 regarding ventilation and gas freeing of enclosed spaces in combination carriers which are to be complied with. In way of cargo holds for oil, enclosed spaces in which explosive gases may accumulate are to be avoided.

12.2 Structural arrangement

12.2.1 Cargo tanks are to facilitate efficient cleaning. Tank boundaries are to have plane surface, corrugated surface or vertical stiffeners as far as practicable. Horizontal primary members are to be avoided inside tanks; where primary structural members are unavoidable, attention is to be paid to the cleaning facilities.

12.2.2 Openings which may be used for cargo operations, for example in the bottom of topside tanks, are not permitted in bulkheads and decks separating oil cargo spaces from other spaces not designed and equipped for the carriage of oil cargoes unless they are equipped with alternative approved means to ensure equivalent integrity.

12.2.3 Where transverse bulkheads in wing tanks have different structural arrangement than in way of the holds, arrangements are to be made to ensure continuity of transverse strength across the longitudinal bulkheads.

12.2.4 Suitable arrangements are to be provided for gas freeing the double bottom, double hull, hopper, side and topside tanks. Similar arrangements are to be provided for cargo oil ducts which are used as pipe tunnels when the ship is carrying dry cargo.

12.3 Hatch covers

12.3.1 The hatch covers and the sealing system are to avoid leakages caused by possible elastic deformation of the hatchways.

12.3.2 The scantlings and arrangement of hatch covers are to be obtained as per Pt.3, Ch.12. Where cargo holds are intended to be partially filled, the hatch covers may require to be additionally strengthened.

12.4 Slop tanks

12.4.1 These requirements are applicable to combination carriers where oil residues are retained in the slop tanks and the ship is otherwise gasfree.

12.4.2 The slop tanks are to be surrounded by cofferdams except where the boundaries are the hull, main cargo deck, cargo pump-room bulkhead or oil fuel bunker tank. These cofferdams are not to be open to a double bottom, pipe tunnel, pump room or other enclosed spaces nor they are to be used for cargo or ballast and are not to be connected to piping systems serving oil cargo or ballast. Means are to be provided for filling the cofferdams with water and draining them. Where the boundary of a slop tank is the cargo pump room bulkhead, the pump room should not be open to the double bottom, pipe tunnel or other enclosed spaces except when they are closed gastight by bolted plates.

12.4.3 Means are to be provided for isolating the piping connecting the pump room with the slop tanks. The means of isolation is to consist of a valve followed by a spectacle flange or a spool piece with appropriate blank flanges. This arrangement is to be located adjacent to the slop tanks, but where this is unreasonable or impracticable it may be located within the pump room directly after the piping penetrates the bulkhead. A separate pumping and piping arrangement is to be provided for discharging the contents of the slop tanks directly over the open deck when the ship is in the dry cargo mode. When the transfer system is used for slop transfer in the dry cargo mode, it is to have no connection to other systems. Separation from other systems by means of removal of spool pieces may be accepted.

12.4.4 Hatches and tank cleaning openings to slop tanks are to be provided only on the open deck and are to be fitted with closing arrangements. Except when they are closed watertight by bolted plates, these closing arrangements are to be provided with locking arrangements, under the control of a responsible ship's officer.

12.4.5 Slop tanks are to be provided with an approved independent venting system, generally in accordance with Sec.8.2.

12.4.6 At least two portable instruments are to be available on board for gas detection.

12.4.7 Adequate ventilation is to be provided for spaces surrounding slop tanks.

12.4.8 Warning notices are to be erected at suitable points detailing the precautions to be observed prior to the ship loading or unloading, or when the ship is carrying dry cargo with liquid in the slop tanks.

12.4.9 Attention is drawn to the requirements of certain Flag state/ Port state Authorities whereby an inert gas system is to be provided for blanketting the slop tank contents.

12.5 Cargo piping

12.5.1 Where cargo wing tanks are provided, cargo oil lines below deck are to be installed inside these tanks. However, IRS may permit cargo oil lines to be placed in special ducts provided these are capable of being adequately cleaned and ventilated to the satisfaction of IRS. Where cargo wing tanks are not provided, cargo oil lines below deck are to be placed in special ducts.

Section 13

Requirements Concerning use of Crude Oil or Slops as Fuel for Tanker Boilers

13.1 In tankers crude oil or slops may be used as fuel for main or auxiliary boilers according to the following requirements. For this purpose all arrangement drawings of a crude oil installation with pipeline layout and safety equipment are to be submitted for approval in each case.

13.2 Crude oil or slops may be taken directly from cargo tanks or from slop tanks or from other suitable tanks. These tanks are to be fitted in the cargo tank area and are to be separated from non-gas-dangerous areas by means of cofferdams with gas-tight bulkheads.

13.3 The construction and workmanship of the boilers and burners are to be proved to be satisfactory in operation with crude oil. The whole surface of the boilers shall be gas-tight separated from the engine room. The boilers themselves are to be tested for gas-tightness before being used. The whole system of pumps, strainers, separators and heaters, if any, shall be fitted in the cargo pump room or in another room, to be considered as dangerous and separated from engine and boiler room by gas-tight bulkheads. When crude oil is heated by steam or hot water the outlet of the heating coils should be led to a separate observation tank installed together with above mentioned components. This closed tank is to be fitted with a venting pipe led to the atmosphere in a safe position according to the rules for tankers and with the outlet fitted with a suitable flame proof wire gauze of corrosion resistant material which is to be easily removable for cleaning.

13.4 Electric, internal combustion and steam (when the steam temperature is higher than 220°C) prime movers of pumps, of separators (if any), etc., shall be fitted in the engine room or in another non-dangerous room. Where drive shafts pass through pump room bulkhead or deck plating, gas-tight glands are to be fitted. The glands are to be efficiently lubricated from outside the pump room.

13.5 Pumps shall be fitted with a pressure relief bypass from delivery to suction side and it shall be possible to stop them by a remote control placed in a position near the boiler fronts or machinery control room and from outside the engine room.

13.6 When it is necessary to preheat crude oil or slops, their temperature is to be automatically controlled and a high temperature alarm is to be fitted.

13.7 The piping for crude oil or slops and the draining pipes for the tray defined in 13.9 are to have a thickness as follows:

External diameter of pipes, d_e thickness, t

OD [mm]	Thickness [mm]
82.5	6.3
88.9 - 108	7.1
114.3 > 139.7	8.0
152.4	8.8

Their connections (to be reduced to a minimum) are to be of the heavy flange type. Within the engine room and boiler room these pipes are to be fitted within a metal duct, which is to be gas-tight and tightly connected to the fore bulkhead separating the pump room and to the tray. This duct (and the enclosed piping) is to be fitted at a distance from the ship's side of at least 20% of the vessel's beam amidships and be at an inclination rising towards the boiler so that the oil naturally returns towards the pump room in the case of leakage or failure in delivery pressure. It is to be fitted with inspection openings with gas-tight doors in way of connections of pipes within it, with an automatic closing drain-trap placed on the pump room side, set in such a way as to discharge leakage of crude oil into the pump room. In order to detect leakages, level position indicators with relevant alarms are to be fitted on the drainage tank defined in 13.9. Also a vent pipe is to be fitted at the highest part of the duct and is to be led to the open in a safe position. The outlet is to be fitted with a suitable flame proof wire gauze of corrosion resistant material which is to be easily removable for cleaning.

The duct is to be permanently connected to an approved inert gas system or steam supply in order to make possible:

- injection of inert gas or steam in the duct in case of fire or leakage

- purging of the duct before carrying out work on the piping in case of leakage.

13.8 In way of the bulkhead to which the duct defined in 13.7 is connected, delivery and return oil pipes are to be fitted on the pump room side, with shut-off valves remotely controlled from a position near the boiler fronts or from the machinery control room. The remote control valves should be interlocked with the hood exhaust fans (defined in 13.10) to ensure that whenever crude oil is circulating the fans are running.

13.9 Boilers shall be fitted with a tray or gutter way of acceptable height and be placed in such a way as to collect any possible oil leakage from burners, valves and connections.

Such a tray or gutter way shall be fitted with a suitable flame proof wire gauze, made of corrosion resistant material and easily dismountable for cleaning. Delivery and return oil pipes shall pass through the tray or gutterway by means of a tight penetration and shall then be connected to the oil supply manifolds.

A quick closing master valve is to be fitted on the oil supply to each boiler manifold. The tray or gutterway shall be fitted with a draining pipe discharging into a collecting tank in pump room. This tank is to be fitted with a venting pipe led to the open in a safe position and with the outlet fitted with wire gauze made of corrosion resistant material and easily dismountable for cleaning. The draining pipe is to be fitted with arrangements to prevent the return of gas to the boiler or engine room.

13.10 Boilers shall be fitted with a suitable hood placed in such a way as to enclose as much as possible of the burners, valves and oil pipes, without preventing, on the other side, air inlet to burner register. The hood, if necessary, is to be fitted with suitable doors placed in such a way as to enable inspection of and access to oil pipes and valves placed behind it. It is to be fitted with a duct leading to the open in a safe position, the outlet of which is to be fitted with a suitable flame wire gauze, easily dismountable for cleaning. At least two mechanically driven exhaust fans having spark proof impellers are to be fitted so that the pressure inside the hood is less than that in the boiler room. The exhaust fans are to be connected with automatic change over in case of stoppage or failure of the one in operation. The exhaust fan prime movers shall be placed outside the duct and a gas-tight bulkhead penetration shall be provided for shaft.

Electrical equipment installed in gas dangerous areas or in areas which may become dangerous (i.e. in the hood or duct in which crude-oil piping is placed) is to be of certified safe type.

13.11 When using fuel oil for delivery to and return from boilers fuel oil burning units in accordance with the Rules shall be fitted in the boiler room. Fuel oil delivery to, and returns from, burners shall be effected by means of suitable mechanical interlocking devices so that running on fuel oil automatically excludes running on crude oil or vice versa.

13.12 The boiler compartments are to be fitted with a mechanical ventilation plant and shall be designed in such a way as to avoid the formation of gas pockets.

Ventilation is to be particularly efficient in way of electrical plants and machinery and other plants which may generate sparks. These plants shall be separated from those for service of other compartments.

13.13 A gas detector plant shall be fitted with intakes in the duct defined in 13.7, in the hood duct (downstream of the exhaust fans in way of the boilers) and in all zones where ventilation may be reduced. An optical warning device is to be installed near the boiler fronts and in the machinery control room. An acoustical alarm, audible in the machinery space and control room, is to be provided.

13.14 Means are to be provided for the boiler to be automatically purged before firing.

13.15 Independent of the fire extinguishing plant as required by the Rules, an additional fire extinguishing plant is to be fitted in the engine and boiler rooms in such a way that it is possible for an approved fire extinguishing medium to be directed on to the boiler fronts and on to the tray defined in 13.9. The emission of extinguishing medium should automatically stop the exhaust fan of the boiler hood.

13.16 A warning notice must be fitted in an easily visible position near the boiler front. This notice must specify that when an explosive mixture is signalled by the gas detector plant defined in 13.13 the watch keepers are to immediately shut off the remote controlled valves on the crude oil delivery and return pipes in the pump room, stop the relative pumps, inject inert gas into the duct defined in 13.7 and turn the boilers to normal running on fuel oil.

13.17 One pilot burner in addition to the normal burning control is required.

Appendix A

List of oils*

Asphalt solutions

Blending stocks
Roofers flux
Straight run residue

Oils

Clarified
Crude oil
Mixtures containing crude oil
Diesel oil
Fuel oil no.4
Fuel oil no.5
Fuel oil no.6
Residual fuel oil
Road oil
Transformer oil
Aromatic oil (excluding vegetable oil)
Lubricating oils and blending stocks
Mineral oil
Motor oil
Penetrating oil
Spindle oil
Turbine oil

Distillates

Straight run
Flashed feed stocks

Gas oil

Cracked

Gasoline blending stocks

Alkylates - fuel
Reformaters
Polymer - fuel

Gasolines

Casinghead (natural)
Automotive
Aviation
Straight run
Fuel oil no.1 (kerosene)
Fuel oil no.1-D
Fuel oil no.2
Fuel oil no.2-D

Jet fuels

JP-1 (kerosene)
JP-3
JP-4
JP-5 (kerosene, heavy)
Turbo fuel
Kerosene
Mineral spirit

Naphtha

Solvent
Petroleum
Heartcut distillate oil

*This list of oils may not necessarily be considered as comprehensive

Appendix B

List of cargoes other than oils which can be carried on oil tankers

Product Name	Pollution Category
Acetone	Z
Alcoholic beverages, n.o.s.	Z
Apple juice	OS
n-Butyl alcohol	Z
sec-Butyl alcohol	Z
Calcium nitrate solutions (50% or less)	Z
Clay slurry	OS
Coal slurry	OS
Diethy lene glycol	Z
Ethyl alcohol	Z
Ethylene carbonate	Z
Glucose solution	OS
Glycerine	Z
Glycerol monooleate	Z
Hexamethylenetetramine solutions	Z
Hexylene glycol	Z
Hydrogenated starch hydrolysate	OS
Isopropyl alcohol	Z
Kaolin slurry	OS
Lecithin	OS
Magnesium hydroxide slurry	Z
Maltitol solution	OS
N-Methylglucamine solution (70% or less)	Z
Methyl propyl ketone	Z
Molasses	OS
Noxious liquid, (11) n.o.s. (trade name …, contains …) Cat.Z	Z
Non-noxious liquid, (12) n.o.s. (trade name …, contains …) Cat OS	OS
Polyaluminium chloride solution	Z
Polyglycerin, sodium salt solution (containing less than 3% sodium hydroxide)	Z
Potassium formate solutions	Z
Propylene carbonate	Z
Propylene glycol	Z
Sodium acetate solutions	Z
Sodium sulphate solutions	Z
Sorbitol solution	OS
Sulphonated polyacrylate solution	Z
Tetraethyl silicate monomer/oligomer (20% in ethanol)	Z
Triethylene glycol	Z
Vegetable protein solution (hydrolysed)	OS
Water	OS
Note 1 : Pollution Category : The letter Z means the Pollution category assigned to each product under Annex II of MARPOL 73/78. OS means the product was evaluated and found to fall outside Categories X, Y or Z.	
Note 2 : Some liquid substances are identified as falling into Pollution Category Z and therefore, subject to certain requirements of Annex II of MARPOL 73/78.	

End of Chapter

Chapter 3

Chemical Carriers

Contents

Introduction

IR 1.0 General

IR 1.1 These Rules have been prepared to ensure that Bulk Chemical Tankers built with a view to classification with Indian Register of Shipping, will also comply with the requirements of the IBC Code, as interpreted by IRS.

IR 1.2 Responsibility for interpretation of the IBC Code requirements for the purpose of issuing an International Certificate of Fitness for Chemical Tankers lies with the Government of the State whose flag the ship is entitled to fly.

IR 1.3 The Rules incorporate the final text of the IBC Code in full. For purpose of classification with Indian Register of Shipping and assignment of the notations provided for in IR 4.0, chemical tankers are required to comply with these Rules and the relevant provisions of IRS Rules and Regulations for the Classification of Ships. The paragraphs which are not included in the IMO code, but have been included in these Rules for the purpose of classification have been prefixed with the letters "IR".

IR 1.4 Ships built prior to the coming-into-force date of these Rules where the provisions of these Rules have not been applied will continue to be dealt with for classification purposes on the basis of the Rules for Chemical Tankers to which these vessels were built. In considering new or additional chemical cargoes for inclusion in the cargo lists of these ships individual consideration, taking account of the ships' arrangements and the nature of the proposed cargoes, will be given.

IR 1.5 For the purpose of classification, the following words in the IMO Code text have been changed as appropriate.

Administration	to	IRS
'Should be'	to	'is to be' or 'are to be'
'Chapter'	to	Section
'Code'	to	Chapter
Section	to	Clause (Cl).

IR 2.0 Ship operational requirements

IR 2.1 The IBC Code contains requirements in respect of operational matters which are not within the scope of classification as defined in the Rules for Ships, but are the responsibility of the National Authority or Administration responsible for issuing the Certificate of Fitness.

IR 2.2 Similarly, operational requirements which appear in the IBC Code will not be dealt with by IRS for classification purposes.

IR 2.3 Those paragraphs which are considered to be operational are indicated in Sec.16.

IR 3.0 Chemicals to which the Code does not apply

IR 3.1 Sec.18 contains a list of chemicals to which the IBC Code does not apply. For classification purposes the carriage of these listed products is therefore not restricted to Chemical Tankers constructed in accordance with these Rules.

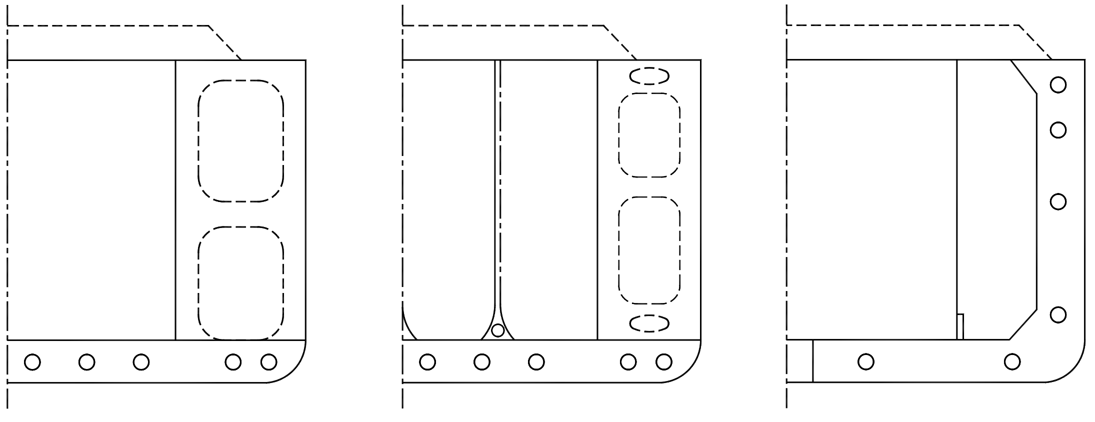

Fig. IR 4.2

IR 4.0 Classification and class notations

IR 4.1 The requirements of this chapter apply to sea going ship's intended primarily to carry chemicals in bulk (i.e. Chemical Tankers) and are supplementary to those given for the assignment of main characters of class.

IR 4.2 Assignment of class notation ESP (Enhanced Survey Program) is mandatory for seagoing self propelled Chemical Tankers which are constructed generally with integral tanks. This notation shall be assigned to chemical tankers of both single or double hull construction, as well as those with alternative structural arrangements. Typical midship sections are given in Fig.IR 4.2.

IR 4.3 Ships complying with the above mentioned requirements as applicable will be eligible to be assigned one of the following class notation:

CHEMICAL TANKER, ESP

in association with a Ship Type notation (Type 1, 2 or 3) and a list of defined cargoes.

IR 4.4 The assignment of Ship Type will not imply that the ship is suitable for all cargoes listed in Sec.17 as requiring that Ship Type. Those cargoes from Sec.17 and 18 for the carriage of which the ship has been approved will be named on a list of Defined Cargoes which will be attached to the Classification Certificate.

IR 4.5 Additional notations

IR 4.5.1 Additional notations may be given for the following features:-

a) Independent tanks, when fitted;

b) Maximum permissible specific gravity for which the scantlings have been approved, where greater than 1.025, e.g. "SG 2.0";

c) Maximum permissible positive pressure/ vacuum relief valve setting for which the scantlings have been approved, where greater than 0.21 bar e.g. "PV + 0.4 bar gauge" ;

d) Tanks constructed of corrosion resistant materials, e.g. stainless steel ("CR (S. Stl)"), or lined with corrosion resistant linings, e.g. rubber lining ("CR (r.l.)");

e) Where temperature control systems are incorporated in compliance with the requirements of Sec.7, the vessel will be eligible for additional notations as follows :

TC (Temperature Control), and where applicable HY(BC) - Refrigerated Machinery (Bulk Chemicals).

IR 4.5.2 Where features given in IR4.5.1 are confined to certain tanks, the tanks concerned will be identified in the notation.

IR 4.5.3 Other notations, as appropriate to the arrangements, scantlings and service, may be assigned.

IR 4.5.4 Chemical tankers will not generally be eligible for a reduction of cargo tank scantlings in association with a corrosion control notation.

IR 5.0 List of defined Cargoes

IR 5.1 The tanks for which each cargo has been approved will be indicated on the list of Defined Cargoes attached to the Classification Certificate as provided for in IR 4.4 together with any specific conditions of carriage.

IR 5.2 Where Chemical Cargoes which are dealt with in these Rules but which are not on the list of Defined Cargoes for classification purposes are to be carried, it will be Owner's responsibility to ensure that particulars are forwarded to IRS for consideration of the classification aspects prior to carriage.

Preamble (To the IBC Code)

1. The purpose of this Code is to provide an international standard for the safe carriage by sea in bulk of dangerous and noxious liquid chemicals listed in Ch.17 of the Code by prescribing the design and construction standards of ships regardless of tonnage, involved in such carriage and the equipment they should carry so as to minimize the risk to the ship, to its crew and to the environment, having regard to the nature of the product involved.

2. The basic philosophy is to assign to each chemical tanker one of the ship types according to the degree of the hazards of the products carried by such ship. Each of the products may have one or more hazard properties which include flammability, toxicity, corrosivity and reactivity, as well as the hazard they may present to the environment if accidentally released.

3. Throughout the development of the Code it was recognized that it must be based upon sound naval architectural and engineering principles and the best understanding available as to the hazards of the various product covered; furthermore that chemical tanker design technology is not only a complex technology but is rapidly evolving and that the Code should not remain static. Therefore the Organization will periodically review the Code taking into account both experience and technical development.

4. Amendments to the Code involving requirements for new products and their conditions of carriage will be circulated as recommendations, on an interim basis, when adopted by the Maritime Safety Committee and the Marine Environment Protection Committee of the Organization, in accordance with the provisions of article VIII of the International Convention for the Safety of Life at Sea, 1974 (SOLAS 74), and article 16 of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol related thereto (MARPOL 73/78) respectively, pending the entry into force of these amendments.

5. The Code primarily deals with ship design and equipment. In order to ensure the safe transport of the products the total system must, however, be appraised. Other important facts of the safe transport of the products, such as training, operation, traffic control and handling in port, are being or will be examined further by the Organization.

6. The development of the Code has been greatly assisted by relevant work of the International Association of Classification Societies (IACS) and of the International Electrotechnical Commission (IEC).

7. Ch.16 of the Code, dealing with operation requirements of chemical tankers, highlights the regulations in other Chapters that are operational in nature and mentions those other important safety features that are peculiar to chemical tanker operation.

8. The layout of the Code is in line with the International Code for the Construction and Equipment of Ship Carrying Liquefied Gases in Bulk (IGC Code), adopted by the Maritime Safety Committee at its forty-eight session. Gas carriers may also carry in bulk liquid chemicals covered by this Code as prescribed in the IGC Code.

9. The 1998 edition of the Code was based on the original text as adopted by MSC resolution MSC.4(48). In response to resolution 15 of the International Conference on Marine Pollution, 1973, the Marine Environment Protection Committee at its twenty-second session, adopted, by resolution MEPC.19(22), the IBC Code extended to cover the marine pollution-prevention aspects for the implementation of Annex II to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78).

10. This edition of the Code includes amendments adopted by the following resolutions:

	Resolution	**Adoption**	**Deemed acceptance**	**Entry into force**
1	MSC.10(54)	29 April 1987	29 April 1988	30 October 1988
2	MSC.14(57)	11 April 1989	12 April 1990	13 October 1990
	MEPC.32(27)	17 March 1989	12 April 1990	13 October 1990
3	MSC.28(61)	11 December 1992	11 January 1994	1 July 1994
	MEPC.55(33)	30 October 1992	11 January 1994	1 July 1994
4	MSC.50(66)	4 June 1996	1 January 1998	1 July 1998
	MEPC.69(38)	10 July 1996	1 January 1998	1 July 1998
5	MSC.58(67)	5 December 1996	1 January 1998	1 July 1998
	MEPC.73(39)	10 March 1997	10 January 1998	10 July 1998
6	MSC.102(73)	5 December 2000	1 January 2002	1 July 2002
7	MSC.176(79)	9 December 2004	1 July 2006	1 January 2007
	MEPC.119(52)	15 October 2004	1 July 2006	1 January 2007
8	MSC 219(82)	8 December 2006	1 July 2008	1 January 2009
	MEPC.166(56)	13 July 2007	1 July 2008	1 January 2009

11. As from the date of entry into force of the 1983 amendments to the 1974 SOLAS Convention (i.e. 1 July 1987) and the date of implementation of Annex II of MARPOL 73/78 (i.e. 6 April 1987), this Code became subject to mandatory requirements under these Conventions. Any future amendment to the Code, whether from the point of view of safety or of marine pollution, must be adopted and brought into force in accordance with the procedures laid down in Article VIII of SOLAS 74 and Article 16 of MARPOL 73/78 respectively.

Section 1

General

1.1 Application

IR 1.1.1 The requirements of this Chapter are in addition to the requirements of Pt.1 to 4 of the Rules as applicable.

1.1.1 This Chapter applies to ships regardless of size, including those of less than 500 tons gross tonnage, engaged in the carriage of bulk cargoes of dangerous or noxious liquid chemical substances, other than petroleum or similar flammable products as follows:

.1 products having significant fire hazards in excess of those of petroleum products and similar flammable products;

.2 products having significant hazards in addition to or other than flammability.

1.1.2 Products that have been reviewed and determined not to present safety and pollution hazards to such an extent as to warrant the application of the Code are found in Sec.18.

1.1.3 Liquids covered by the Chapter are those having a vapour pressure not exceeding 0.28 MPa at a temperature of 37.8°C.

1.1.4 For the purpose of the 1974 SOLAS Convention, the Chapter applies to ships which are engaged in the carriage of products included in Sec.17 on the basis of their safety characteristics and identified as such by an entry of S or S/P in column d.

1.1.5 For the purposes of MARPOL 73/78, the Code applies only to NLS tankers, as defined in regulation 1.16.2 of Annex II thereof, which are engaged in the carriage of Noxious Liquid Substances identified as such by an entry of X, Y or Z in column c of Section 17.

1.1.6 For a product proposed for carriage in bulk, but not listed in Sec.17 or 18, the Administration and port Administrations involved in such carriage should prescribe the preliminary suitable conditions for the carriage, having regard to the criteria for hazard evaluation of bulk chemicals. The Organization should be notified of the conditions for consideration for inclusion of the product in the Code. For the evaluation of the pollution hazard of such a product and assignment of its pollution category, the procedure specified in regulation 6.3 of Annex II of MARPOL 73/78 must be followed.

IR 1.1.6 Products covered in 1.1.6 will be specially considered by IRS.

1.1.7 Unless expressly provided otherwise the Chapter applies to ships the keels of which are at a stage at which:

.1 construction identifiable with the ship begins; and

.2 assembly has commenced comprising at least 50 tonnes or 1% of the estimated mass of all structural material, whichever is less;

on or after 1 July 1986.

IR 1.1.7 For classification purposes these Rules may, but need not be, applied to ships for which the midship section is approved prior to 1 July 1986.

1.1.8 A ship, irrespective of the date of construction, which is converted to a chemical tanker on or after 1 July 1986, is to be treated as a chemical tanker constructed on the date on which such conversion commences. This conversion provision does not apply to the modification of a ship referred to in regulation 1(12) of Annex II of MARPOL 73/78.

1.1.9 Where reference is made in the Chapter to a paragraph, all the provisions of the subparagraphs of that designation will apply.

1.2 Hazards

Hazards of products covered by this Chapter include:

1.2.1 Fire hazard defined by flashpoint, boiling point, flammability limits and auto-ignition temperature of the chemical.

1.2.2 Health hazard defined by:

.1 corrosive effects on the skin in the liquid state; or

.2 acute toxic effect, taking into account values of

LD_{50} (oral): a dose which is lethal to 50% of the test subjects when administered orally;

LD_{50} (dermal) : a dose which is lethal to 50% of the test subjects when administered to the skin;

LC_{50} (inhalation): the concentration which is lethal by inhalation to 50% of the test subjects.

.3 other health effects such as carcinogenicity and sensitization.

1.2.3 Reactivity hazard defined by reactivity :

.1 with water;
.2 with air;
.3 with other products; or
.4 of the product itself (e.g.polymerization).

1.2.4 Marine pollution hazard as defined by:

.1 bioaccumulation;

.2 lack of ready biodegradibility;

.3 acute toxicity to aquatic organisms;

.4 chronic toxicity to aquatic organisms;

.5 long term human health effects; and

.6 physical properties resulting in the product floating or sinking and so adversely affecting marine life.

1.3 Definitions

The following definitions apply unless expressly provided otherwise. (Additional definitions are given in individual chapters).

1.3.1 **Accommodation spaces** are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces. Public spaces are those portions of the accommodation spaces which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

1.3.2.1 **Administration** means the Government of the State whose flag the ship is entitled to fly.

1.3.2.2 **Port administration** means the appropriate authority of the country in the port which the ship is loading or unloading.

1.3.3 **Boiling point** is the temperature at which a product exhibits a vapour pressure equal to the atmospheric pressure.

1.3.4 **Breadth (B**) means the maximum breadth of the ship, measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material. The breadth (B) is to be measured in metres [m].

IR 1.3.1 For the purpose of ca lculation of scantlings, Pt.3 of the Rules is to be referred for the definition of "Breadth".

1.3.5 **Cargo area** is that part of the ship that contains cargo tanks, slop tanks, cargo pump-rooms including pump-rooms, cofferdams, ballast or void spaces adjacent to cargo tanks or slop tanks and also deck areas throughout the entire length and breadth of the part of the ship over the above-mentioned spaces. Where independent tanks are installed in hold spaces, cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forwardmost hold space are excluded from the cargo area.

1.3.6 **Cargo pump-room** is a space containing pumps and their accessories for the handling of the products covered by this Chapter.

1.3.7 Cargo service spaces are spaces within the cargo area used for workshops, lockers and store-rooms of more than 2 [m^2] in area, used for cargo-handling equipment.

1.3.8 **Cargo tank** is the envelope designed to contain the cargo.

1.3.9 **Chemical tanker** is a cargo ship constructed or adapted and used for the carriage in bulk of any liquid product listed in Sec.17.

1.3.10 **Cofferdam** is the isolating space between two adjacent steel bulkheads or decks. This space may be a void space or a ballast space.

1.3.11 **Control stations** are those spaces in which ship's radio or main navigating equipment or the emergency source of power is located or where the fire-recording or fire-control equipment is centralized. This does not include special fire-control equipment which can be most practically located in the cargo area.

1.3.12 **Dangerous chemicals** means any liquid chemicals designated as presenting a safety hazard, based on the safety criteria for assigning products to chapter 17.

1.3.13 **Density** is the ratio of the mass to the volume of a product, expressed in terms of kilograms per cubic metre. This applies to liquids, gases and vapours.

1.3.14 **Explosive/Flammability limits/range** are the conditions defining the state of fuel-air mixture at which application of an adequately strong external ignition source is only just capable of producing flammability in a given test apparatus.

1.3.15 **Flashpoint** is the temperature in degrees Celsius at which a product will give off enough flammable vapour to be ignited. Values given in this Chapter are "closed cup test" determined by an approved flashpoint apparatus.

1.3.16 **Hold space** is the space enclosed by the ship's structure in which an independent cargo tank is situated.

1.3.17 **Independent** means that a piping or venting system, for example, is in no way connected to another system and that there are no provisions available for the potential connection to other systems.

1.3.18 **Length (L)** means 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that be greater. In ships designed with rake of keel, the waterline on which this length is measured is to be parallel to the designed waterline. The length (L) is to measured in metres [m].

IR 1.3.18A For the purpose of calculation of scantlings, Pt.3 of the Rules is to be referred for the definition of "Length".

1.3.19 **Machinery spaces of category A** are those spaces and trunks to such spaces which contain:

.1 internal combustion machinery used for main propulsion; or

.2 internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 [kW]; or

.3 any oil-fired boiler or oil fuel unit.

1.3.20 **Machinery spaces** are all machinery spaces of category A and all other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air-conditioning machinery, and similar spaces, and trunks to such spaces.

1.3.21 **MARPOL 73/78** means the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto.

1.3.22 **Noxious Liquid Substance** means any substance indicated in the Pollution Category column of chapters 17 or 18 of the International Bulk Chemical Code, or the current MEPC.2/Circular or provisionally assessed under the provisions of regulation 6.3 of MARPOL Annex II as falling into categories X, Y or Z.

1.3.23 **Oil fuel unit** is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 1.8 bar gauge.

1.3.24 **Organization** is the International Maritime Organization (IMO).

1.3.25 **Permeability** of a space means the ratio of the volume within that space which is assumed to be occupied by water to the total volume of that space.

1.3.26 **Products** is the collective term used to cover both Noxious Liquid Substances and Dangerous Chemicals.

1.3.27 **Pump-room** is a space, located in the cargo area, containing pumps and their accessories for the handling of ballast and oil fuel.

1.3.28 **Recognized standards** are applicable international or national standards acceptable to the Administration or standards laid down and maintained by an organization which complies with the standards adopted by IMO and which is recognised by the Administration.

(Refer to the Minimum Standards for Recognised Organisation Acting on Behalf of the Administration, set out in Appendix 1 to the Guidelines for the Authorization of Organisations Acting on Behalf of the Administration adopted by the Organisation by Resolution A.739(18)).

1.3.29 **Reference temperature** is the temperature at which the vapour pressure of the cargo corresponds to the set pressure of the pressure-relief valve.

1.3.30 **Separate** means that a cargo piping system or cargo vent system, for example, is not connected to another cargo piping or cargo vent system.

1.3.31 **Service areas** are those spaces used for galleys, containing appliances, lockers, mail and specie rooms, store-rooms, workshop other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

1.3.32 **SOLAS** means the International Convention for the Safety of Life at Sea, 1974, as amended.

1.3.32A **Standards for procedures and arrangements** means Standards for the Procedures and Arrangements for the Discharge of Noxious Liquid Substances called for by Annex II of MARPOL 73/78 adopted by the Marine Environment Protection Committee at its twenty-second session by resolution MEPC 18(22) as may be amended by the Organization.

1.3.33 **Vapour pressure** is the equilibrium pressure of the saturated vapour above the liquid expressed in bars absolute at a specified temperature.

1.3.34 **Void space** is an enclosed space in the cargo area external to a cargo tank, other than a hold space, ballast space, oil fuel tank, cargo pump-room, pump-room, or any space in normal use by personnel.

1.3.35 **Purging** means the introduction of inert gas into a tank which is already in an inert condition with the object of further reducing the oxygen content; and/or reducing the existing hydrocarbon or other flammable vapours content to a level below which combustion cannot be supported if air is subsequently introduced into the tank.

1.3.36 **Gas-freeing** means the process where a portable or fixed ventilation system is used to introduce fresh air into a tank in order to reduce the concentration of hazardous gases or vapours to a level safe for tank entry. Gas freeing is to be carried out after purging.

1.4 Equivalents

IR 1.4.1 The construction, equipment, etc. which do not comply with the provisions of these Rules but are considered to be equivalent to these Rules would be specially considered by IRS.

1.4.1 Where the Chapter requires that a particular fitting, material, appliance, apparatus, item of equipment or type thereof is to be fitted or carried in a ship, or that any particular provision should be made, or any procedure or arrangement is to be complied with, the Administration may allow any other fitting, material, appliance, apparatus, item of equipment or type thereof to be fitted or carried, or any other provision, procedure or arrangement to be made in that ship, if it is satisfied by trial thereof or otherwise that such fitting, material, appliance, apparatus, item of equipment or type thereof or that any particular provision, procedure or arrangement is at least as effective as that required by the Chapter. However, the Administration may not allow operational methods or procedures to be made an alternative to a particular fitting, material appliance, apparatus, item of equipment, or type thereof, which are prescribed by the Chapter, unless such substitution is specifically allowed by the Chapter.

1.4.2 When the Administration so allows any fitting, material, appliance, apparatus, item of equipment, or type thereof, or provision, procedure, or arrangement, or novel design or application to be substituted thereafter, it should communicate to the Organization the particulars thereof together with a report on the evidence submitted so that the Organization may circulate the same to other Contracting Governments to SOLAS and parties to MARPOL for the information of their officers.

1.5 Surveys and certification

1.5.1 Survey procedure

IR 1.5.1.1 The survey of ships with regard to the classification of the ship is to be carried out by the Surveyors of IRS.

1.5.1.1 The survey of ships so far as regards the enforcement of the provisions of the regulations and granting of exemptions therefrom, should be carried out by the officers of the Administration. The Administration may, however, entrust the surveys either to Surveyors nominated for the purpose or to organisations recognized by it.

1.5.1.2 The Administration nominating surveyors or recognising organizations to conduct surveys should, as a minimum, empower any nominated surveyor or recognized organization to:

.1 require repairs to a ship; and

.2 carry out surveys if requested by the port State authority concerned.

The Administration should notify the Organization of the specific responsibilities and condition of the authority delegated to nominated surveyors or recognized organization for circulation to the Contracting Governments.

1.5.1.3 When a nominated surveyor or recognized organization determines that the condition of the ship or its equipment does not correspond substantially with the particulars of the certificates or is such that the ship is not fit to proceed to sea without danger to the ship, or persons on board, such surveyor or organization should immediately ensure that corrective action is taken and should in due course notify the Administration. If such corrective action is not taken the relevant certificate should be withdrawn immediately; and, if the ship is in a port of another Contracting Government, the Port State authority concerned should also be notified immediately.

1.5.1.4 In every case, the Administration should guarantee the completeness and efficiency of the survey, and should undertake to ensure the necessary arrangements to satisfy this obligation.

1.5.2 Survey requirements

IR 1.5.2.1 The Classification Regulations for New Construction Surveys, the classification of ships not built under Survey and Periodical Survey Regulations are given in Pt.1 of the Rules. The following requirements are also to be complied with.

1.5.2.1 The structure, equipment, fittings, arrangements and material (other than items in respect of which a Cargo Ship Safety Construction Certificate, Cargo Ship Safety Equipment Certificate and Cargo Ship Safety Radiotelegraphy Certificate or Cargo Ship Safety Radiotelephony Certificate are issued) of a chemical tanker should be subjected to the following surveys:

.1 An initial survey before the ship is put in service or before the International Certificate of Fitness for the Carriage of Dangerous Chemical in Bulk is issued for the first time, which should include a complete examination of its structure, equipment, fittings, arrangements and material in so far as the ship is covered by the Code. This survey should be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of the Code.

.2 A periodical survey at intervals specified by the Administration, but not exceeding 5 years which should be such as to ensure that the structure, equipment, fittings, arrangements and material comply with the applicable provisions of the Code.

.3 A minimum of one intermediate survey within 3 months before or after the second anniversary date or within 3 months before or after the third anniversary date of the certificate, which shall take the place of one of the annual surveys specified in 1.5.2.1.4. Intermediate surveys should be such as to ensure that the safety equipment, and other equipment, and associated pump and piping systems comply with the applicable provisions of the Code and are in good working order. Such surveys should be endorsed on the International Certificate of fitness for the Carriage of Dangerous Chemicals in Bulk.

IR.3 Those items which are additional to the requirements of Annual Survey may be examined between the second or third annual survey.

.4 A mandatory annual survey within 3 months before or after the anniversary of the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk which should include a general examination to ensure that the structure, equipment, fittings, arrangements and materials remain in all respects satisfactory for the service for which the ship is intended. Such a survey should be endorsed in the International Certificate of Fitness for the Carriage of Dangerous Chemicals in bulk.

.5 An additional survey, either general or partial according to the circumstances, should be made when required after an investigation prescribed in 1.5.3.3 or whenever any important repairs or renewals are made. Such a survey should ensure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are satisfactory; and that the ship is fit to proceed to sea without danger to the ship or persons on board or without presenting unreasonable threat of harm to the marine environment.

1.5.3 Maintenance of conditions after survey

1.5.3.1 The condition of the ship and its equipment should be maintained to confirm with the provisions of the Code to ensure that the ship will remain fit to proceed to sea without danger to the ship or persons on board or without presenting an unreasonable threat of harm to the marine environment.

1.5.3.2 After any survey of the ship under 1.5.2 has been completed, no change should be made in the structure, equipment, fittings, arrangements and material covered by the survey, without the sanction of the Administration, except by direct replacement.

1.5.3.3 Whenever an accident occurs to a ship or a defect is discovered, either of which affects the safety of the ship or the efficiency or completeness of its life-saving appliances or other equipment, the master or owner of the ship should report at the earliest opportunity to the Administration, the nominated surveyor or recognised organization responsible for issuing the relevant certificate, who should cause investigations to be initiated to determine whether a survey, as required by 1.5.2.1.5 is necessary. If the ship is in a port of another Contracting Government, the master or owner should also report immediately to the port State authority concerned and the nominated surveyor or recognised organization should ascertain that such a report has been made.

1.5.4 Issue of International certificate of fitness

1.5.4.1 An International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk the model form of which is set out in the appendix to the Code, should be issued after an initial or periodical survey to a chemical tanker engaged in international voyages which complies with the relevant requirements of the Code.

1.5.4.2 The certificate issued under provisions of this Section should be available on board for inspection at all times.

1.5.5 Issue or endorsement of International certificate of fitness by another Government

1.5.5.1 A Party to the 1974 SOLAS Convention and to MARPOL 73/78 may, at the request of another Party, cause a ship entitled to fly the flag of the other State to be surveyed and, if satisfied that the requirements of the Code are complied with, issue or authorise the issue of the certificate to the ship, and, where appropriate, endorse or authorise the endorsement of the certificate on board the ship in accordance with the Code. Any certificate so issued should contain a statement to the effect that it has been issued at the request of the Government of the State whose flag the ship is entitled to fly.

1.5.6 Duration and validity of the International certificate of fitness

1.5.6.1 An International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk should be issued for a period specified by the Administration which should not exceed 5 years.

1.5.6.2 No extension of the 5 years period of the certificate should be permitted.

1.5.6.2.1 Notwithstanding the provisions of 1.5.6.1, when the renewal survey is completed within 3 months before the expiry date of the existing certificate, the new certificate shall be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of expiry of the existing certificate.

1.5.6.2.2 When the renewal survey is completed after the expiry date of the existing certificate, the new certificate shall be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of expiry of the existing certificate.

1.5.6.2.3 When the renewal survey is completed more than 3 months before the expiry date of the existing certificate, the new certificate shall be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of completion of the renewal survey.

1.5.6.3 If a certificate is issued for a period of less than 5 years, IRS may extend the validity of the certificate beyond the expiry date to the maximum period specified in 1.5.6.1, provided that the surveys referred to in 1.5.2.1.3 and 1.5.2.1.4, applicable when a certificate is issued for a period of 5 years, are carried out as appropriate.

1.5.6.4 If a renewal survey has been completed and a new certificate cannot be issued or placed on board the ship before the expiry date of the existing certificate, the Surveyor may endorse the existing certificate. Such a certificate shall be accepted as valid for a further period which shall not exceed 5 months from the expiry date.

1.5.6.5 If a ship, at the time when a certificate expires, is not in a port in which it is to be surveyed, IRS may extend the period of validity of the certificate but this extension shall be granted only for the purpose of allowing the ship to complete its voyage to the port in which it is to be surveyed, and then only in cases where it appears proper and reasonable.

1.5.6.6 A certificate, issued to a ship engaged on short voyages which has not been extended under the foregoing provisions of this section, may be extended by the Administration for a period of grace of up to one month from the date of expiry stated on it. When the renewal survey is completed, the new certificate shall be valid to a date not exceeding 5 years from the date of expiry of the existing certificate before the extension was granted.

1.5.6.7 In special circumstances, as determined by the Administration, a new certificate need not be dated from the date of expiry of the existing certificate as required by 1.5.6.2.2, 1.5.6.5 or 1.5.6.6. In these special circumstances, the new certificate shall be valid to a date not exceeding 5 years from the date of completion of the renewal survey.

1.5.6.8 If an annual or intermediate survey is completed before the period specified in 1.5.2, then:

.1 the anniversary date shown on the certificate shall be amended by endorsement to a date which shall not be more than 3 months later than the date on which the survey was completed;

.2 the subsequent annual or intermediate survey required by 1.5.2 shall be completed at the intervals prescribed by that section using the new anniversary date; and

.3 the expiry date may remain unchanged provided one or more annual or intermediate surveys, as appropriate, are carried out so that the maximum intervals between the surveys prescribed by 1.5.2 are not exceeded.

1.5.6.9 The certificate issued under 1.5.4 or 1.5.5 should cease to be valid in any of the following cases:

.1 if the relevant surveys are not completed within the periods specified under 1.5.2;

.2 if the Certificate is not endorsed in accordance with 1.5.2.1.3 or 1.5.2.1.4;

.3 upon transfer of the ship to the flag of another State. A new certificate should only be issued when the Government issuing the new certificate is fully satisfied that the ship is in compliance with the requirements of 1.5.3.1 and 1.5.3.2. In the case of a transfer between Governments that are both a Contacting Government to the 1974 SOLAS Convention and a party to MARPOL 73/78, if requested within 3 months after the transfer has taken place, the Government of the State whose flag the ship was formerly entitled to fly shall, as soon as possible transmit to the Administration copies of the certificates carried by the ship before the transfer and, if available, copies of the relevant survey reports.

IR 1.6 Plans and particulars

IR 1.6.1 A general arrangement is to be submitted for approval giving location of:

- cargo hatches, tank cleaning hatches and any other openings to the cargo tanks.

- doors, hatches and any other openings to pump rooms and other gas-dangerous spaces.

- ventilating pipes and openings for cargo tanks, pump rooms and other gas-dangerous spaces.

- doors, air locks, hatches, ventilating pipes and openings, hinged scuttles which can be opened, and other openings to gas safe spaces adjacent to the cargo area including spaces in and below the forecastle.

- cargo pipes and gas return pipes over the deck with shore-connections including stern pipes for cargo discharge or gas-freeing of cargo tanks.

- deckplan showing location and type of all monitoring equipment for cargo handling such as, level gauging, overflow control, temperature read out etc.

IR 1.6.2 Plans with the following particulars for the tanks are to be submitted for approval:

- drawings of cargo tanks including information on non-destructive testing of welds and strength and tightness testing of tanks.

- drawings of support and staying of independent cargo tanks.

- a complete stress analysis is to be submitted for pressure tanks.

- damage stability calculations.

IR 1.6.3 Plans of the following pumping and piping arrangements with accessories are to be submitted for approval:

- diagrams of the cargo piping system including details such as expansion elements and flange connections.

- bilge piping systems in pump rooms, cofferdams, pipe tunnels and hold spaces.
- arrangement for drainage of cargo pumps and piping in the pumproom.
- drawing of cargo pump.
- arrangements for cargo tank stripping and drainage/stripping of cargo lines.
- diagram of tank washing.
- arrangement and location of underwater discharge outlet(s).

IR 1.6.4 Plans showing the following equipment and systems are to be submitted for approval:

- arrangement and capacity of air ducts, fans and their motors in the cargo area, drawing and material specification of rotating parts and casing of the fans.
- drawings of portable ventilators and drawings showing where and how these are to be fitted.
- arrangement for gas-freeing of cargo tanks and cargo lines. Arrangement of cargo tank venting systems.
- arrangement and specification of all monitoring systems and devices for liquid level indication.
- quick-closing arrangements for cargo valves.
- drawings of gastight bulkhead stuffing boxes.
- arrangement of cargo heating systems.
- arrangement of cargo cooling systems.
- arrangement of possible thermal insulation and specification of insulation materials.
- drawings showing details of design, attachment and location of anodes and other fittings in tanks and cofferdams.

IR 1.6.5 Plans of electrical installations giving the following particulars are to be submitted for approval:

- area classification drawings.
- drawings showing location of all electrical equipment in gas dangerous area.
- single line diagram for intrinsically safe circuits.
- list of explosion protected equipment with reference to drawings together with certificates.

Section 2

Ship Survival Capability and Location of Cargo Tanks

2.1 General

2.1.1 Ships subject to the requirements of this Chapter are to survive the normal effects of flooding following assumed hull damage caused by some external force. In addition, to safeguard the ship and the environment, the cargo tanks of certain types of ships are to be protected from penetration in the case of minor damage to the ship resulting, for example, from contact with a jetty or tug, and given a measure of protection from damage in the case of collision or stranding, by locating them at specified minimum distances inboard from the ship's shell plating. Both the damage to be assumed and the proximity of the cargo tanks to the ship's shell is to be dependent upon the degree of hazard presented by the products to be carried.

2.1.2 Ships subject to the requirements of this Chapter are to be designed to one of the following standards:

.1 **A Type 1 ship** is a chemical tanker intended to transport products listed in Sec.17 with very severe environmental and safety hazards which require maximum preventive measures to preclude an escape of such cargo.

.2 **A Type 2 ship** is a chemical tanker intended to transport products listed in Sec.17 with appreciably severe environmental and safety hazards which require significant preventive measures to preclude an escape of such cargo.

.3 **A Type 3 ship** is a chemical tanker intended to transport products listed in Sec.17 with sufficiently severe environmental and safety hazards which require a moderate degree of containment to increase survival capability in a damaged condition.

Thus a Type 1 ship is a chemical tanker intended for the transportation of products considered to present the greatest overall hazard and Type 2 and Type 3 for products of progressively lesser hazards. Accordingly, a Type 1 ship is to survive the most severe standard of damage and its cargo tanks are to be located at the maximum prescribed distance inboard from the shell plating.

2.1.3 The ship type required for individual products is indicated in column "e" in the Table 17.1.1.

2.1.4 If a ship is intended to carry more than one product listed in Sec.17, the standard of damage is to correspond to that product having the most stringent ship type requirement. The requirements for the location of individual cargo tanks, however, are those for ship types related to the respective products intended to be carried.

2.2 Freeboard and stability

2.2.1 Ships subject to this Chapter may be assigned the minimum freeboard permitted by the International Convention on Load Lines in force. However, the draught associated with the assignment is not to be greater than the maximum draught otherwise permitted by this Chapter.

2.2.2 The stability of the ship in all seagoing conditions is to be to a standard which is acceptable to the Administration.

2.2.3 When calculating the effect of free surfaces of consumable liquids for loading conditions it is to be assumed that, for each type of liquid, at least one transverse pair or a single centre tank has a free surface and the tank or combination of tanks to be taken in to account is to be that where the effect of the free surfaces is the greatest. The free surface effect in undamaged compartments is to be calculated by a method acceptable to the Administration.

2.2.4 Solid ballast is not normally to be used in double bottom spaces in the cargo area. Where, however, because of stability considerations, the fitting of solid ballast in such spaces becomes unavoidable, then its disposition is to be governed by the need to ensure that the impact loads resulting from bottom damage are not directly transmitted to the cargo tank structure.

2.2.5 The master of the ship is to be supplied with a loading and stability information booklet. This booklet is to contain details of typical service and ballast conditions, provisions for evaluating other conditions of loading and a summary of the ship's survival capabilities. In addition, the booklet is to contain sufficient information to enable the master to load and operate the ship in a safe and seaworthy manner.

2.2.6 All ships, subject to the requirements of this Chapter, are to be fitted with a stability instrument, capable of verifying compliance with intact and damage stability requirements, approved by the Administration/ IRS, having regard to the recommended performance standards

(Refer to Part B, Chapter 4, of the International Code on Intact Stability, 2008 (2008 IS Code), as amended; the Guidelines for the Approval of Stability Instruments (MSC.1/Circ.1229), Annex, Section 4, as amended; and the technical standards defined in Part 1 of the Guidelines for verification of damage stability requirements for tankers (MSC.1/Circ.1461)

.1 ships constructed before 1 January 2016 are to comply with this requirement at the first scheduled renewal survey of the ship on or after 1 January 2016 but not later than 1 January 2021;

.2 notwithstanding the requirements of 2.2.6.1, a stability instrument fitted on a ship constructed before 1 January 2016 need not be replaced provided it is capable of verifying compliance with intact and damage stability, to the satisfaction of the Administration/ IRS; and

.3 for the purposes of control under regulation 16 of MARPOL Annex II, the Administration/ IRS may issue a document of approval for the stability instrument.

2.2.7 The Administration may waive the requirements of 2.2.6 for the following ships provided the procedures employed for intact and damage stability verification maintain the same degree of safety, as being loaded in accordance with the approved conditions *(Refer to operational guidance provided in Part 2 of the guidelines for verification of damage stability requirements for tankers (MSC.1/Circ.1461).* Any such waiver would be duly noted on the International Certificate of Fitness referred to in 1.5.4:

.1 ships which are on a dedicated service, with a limited number of permutations of loading such that all anticipated conditions have been approved in the stability information provided to the master in accordance with the requirements of 2.2.5;

.2 ships where stability verification is made remotely by a means approved by the Administration/ IRS;

.3 ships which are loaded within an approved range of loading conditions; or

.4 ships constructed before 1 January 2016 provided with approved limiting KG/ GM curves covering all applicable intact and damage stability requirements.

2.3 Shipside discharges below the freeboard deck

2.3.1 The provision and control of valves fitted to discharges led through the shell from spaces below the freeboard deck or from within the superstructures and deckhouses on the freeboard deck fitted with weathertight doors are to comply with the requirements of the relevant regulation of the International Convention on Load Lines in force, except that the choice of valves is to be limited to:

.1 one automatic nonreturn valve with a positive means of closing from above the freeboard deck; or

.2 where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0.01L, two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions.

2.3.2 For the purpose of this Chapter "summer waterline" and "freeboard deck", have the meanings as defined in the International Convention on Load Lines in force.

2.3.3 The automatic nonreturn valves referred to in 2.3.1 are to comply with recognized standards and are to be fully effective in preventing admission of water into the ship, taking into account the sinkage, trim and heel in survival requirements given in 2.9.

2.4 Conditions of loading

2.4.1 Damage survival capability is to be investigated on the basis of the loading information submitted to IRS for all anticipated conditions of loading and variations in draught and trim. Ballast conditions where the chemical tanker is not carrying products covered by this Chapter, or is carrying only residues of such products, need not be considered.

2.5 Damage assumptions

2.5.1 The assumed maximum extent of damage is to be :

Side damage		
Longitudinal extent	$\frac{1}{3}$ $L^{2/3}$ or 14.5 [m], whichever is less	
Transverse extent	B/5 or 11.5 [m], whichever is less (measured inboard from the ship's side at the right angles to the centreline at the level of the summer load line)	
Vertical extent	upwards without limit (from the moulded line of the bottom shell plating at centreline)	
Bottom damage		
	For 0.3L from the forward perpendicular of the ship	Any other part of the ship
Longitudi-nal extent	$\frac{1}{3}$ $L^{2/3}$ or 14.5 [m], whichever is less	$\frac{1}{3}$ $L^{2/3}$ or 5 [m], whichever is less
Transver-se extent	B/6 or 10 [m], whichever is less	B/6 or 5 [m], whichever is less
Vertical extent	B/15 or 6 [m], whichever is less. (measured from the moulded line of the bottom shell plating at centreline (see 2.6.2))	B/15 or 6 [m], whichever is less. (measured from the moulded line of the bottom shell plating at centreline (see 2.6.2))

2.5.2 If any damage of a lesser extent than the maximum damage specified in 2.5.1 would result in a more severe condition, such damage is to be considered.

2.6 Location of cargo tanks

2.6.1 Cargo tanks are to be located at the following distances inboard:

.1 Type 1 ships : from the side shell plating not less than the transverse extent of damage specified in table above titled 'Side damage' and from the moulded line of the bottom shell plating at centreline not less than the vertical extent of damage specified in table above titled 'Bottom damage' and nowhere less than 760 [mm] from the shell plating. This requirement does not apply to the tanks for diluted slops arising from tank washing.

.2 Type 2 ships : from the moulded line of the bottom shell plating at centreline, not less than the vertical extent of damage specified in table above titled 'Bottom damage' and nowhere less than 760 [mm] from the shell plating. This requirement does not apply to the tanks for diluted slops arising from tank washing.

.3 Type 3 ships : no requirement.

2.6.2 Except for Type 1 ships, suction wells installed in cargo tanks may protrude into the vertical extent of bottom damage specified in table above titled 'Bottom damage' provided that such wells are as small as practicable and the protrusion below the inner bottom plating does not exceed 25% of the depth of the double bottom or 350 [mm], whichever is less. Where there is no double bottom, the protrusion of the suction well of independent tanks below the upper limit of bottom damage is not to exceed 350 [mm]. Suction wells installed in accordance with this paragraph may be ignored in determining the compartments affected by damage.

2.7 Flooding assumptions

2.7.1 The requirements of 2.9 are to be confirmed by calculations which take into consideration the design characteristics of the ship; the arrangements, configuration and contents of the damaged compartments; the distribution, relative densities and the free surface effects of liquids; and the draught and trim for all conditions of loading.

2.7.2 The permeabilities of spaces assumed to be damaged are to be as follows:

Spaces	Permeabilities
Appropriated to stores	0.60
Occupied by accommodation	0.95
Occupied by machinery	0.85
Voids	0.95
Intended for consumable liquids	0 to 0.95*
Intended for other liquids	0 to 0.95*
* The permeability of partially filled compartments is to be consistent with the amount of liquid carried in the compartment.	

2.7.3 Wherever damage penetrates a tank containing liquids it is to be assumed that the contents are completely lost from that compartment and replaced by salt water up to the level of the final plane of equilibrium.

2.7.4 Every watertight division within the maximum extent of damage defined in 2.5.1 and considered to have sustained damage in positions given in 2.8.1 is to be assumed to be penetrated. Where damage less than the maximum is being considered in accordance with 2.5.2, only watertight divisions or combinations of watertight divisions within the envelope of such lesser damage is to be assumed to be penetrated.

2.7.5 The ship is to be so designed as to keep unsymmetrical flooding to the minimum consistent with efficient arrangements.

2.7.6 Equalization arrangements requiring mechanical aids such as valves or cross-levelling pipes, if fitted, are to be considered for the purpose of reducing an angle of heel or attaining the minimum range of residual stability to meet the requirements of 2.9 and sufficient residual stability is to be maintained during all stages where equalization is used. Spaces which are linked by ducts of large cross-sectional area may be considered to be common.

2.7.7 If pipes, ducts, trunks or tunnels are situated within the assumed extent of damage penetration, as defined in 2.5, arrangements are to be such that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage.

2.7.8 The buoyancy of any superstructure directly above the side damage is to be disregarded. The unflooded parts of superstructures beyond the extent of damage, however, may be taken into consideration provided that:

.1 they are separated from the damaged space by watertight divisions and the requirements of 2.9.3 in respect of these intact spaces are complied with; and

.2 openings in such divisions are capable of being closed by remotely operated sliding watertight doors and unprotected openings are not immersed within the minimum range of residual stability required in 2.9; however the immersion of any other openings capable of being closed weathertight may be permitted.

2.8 Standard of damage

2.8.1 Ships are to be capable of surviving the damage indicated in 2.5 with the flooding assumptions in 2.7 to the extent determined by the ship's type according to the following standards:

.1 A Type 1 ship is to be assumed to sustain damage anywhere in its length;

.2 A Type 2 ship of more than 150 [m] in length is to be assumed to sustain damage anywhere in its length;

.3 A Type 2 ship of 150 [m] in length or less is to be assumed to sustain damage anywhere in its length except involving either of the bulkheads bounding a machinery space located aft;

.4 A Type 3 ship of more than 225 [m] in length is to be assumed to sustain damage anywhere in its length;

.5 A Type 3 ship of 125 [m] in length or more but not exceeding 225 m in length is to be assumed to sustain damage anywhere in its length except involving either of the bulkheads bounding a machinery space located aft;

.6 A Type 3 ship below 125 [m] in length is to be assumed to sustain damage anywhere in its length except involving damage to the machinery space when located aft. However, the ability to survive the flooding of the machinery spaces would be considered by IRS.

2.8.2 In the case of small Type 2 and Type 3 ships which do not comply in all respects with the appropriate requirements of 2.8.1.3 and 2.8.1.6, special dispensation may only be considered by the Administration provided that alternative measures can be taken which maintain the same degree of safety. The nature of the alternative measures are to be approved and clearly stated and be available to the Port Administration. Any such dispensation is to be duly noted on the International Certificate of fitness referred to in 1.5.4.

2.9 Survival requirements

2.9.1 Ships subject to this Chapter are to be capable of surviving the assumed damage specified in 2.5 to the standard provided in 2.8 in a condition of stable equilibrium and are to satisfy the following criteria.

2.9.2 In any stage of flooding:

.1 the waterline, taking into account sinkage, heel and trim, are to be below the lower edge of any opening through which progressive flooding or down-flooding may take place. Such openings are to include air pipes and openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors, and sidescuttles of the non-opening type;

.2 the maximum angle of heel due to unsymmetrical flooding is not to exceed 25°, except that this angle may be increased to 30° if no deck immersion occurs;

.3 the residual stability during intermediate stages of flooding is to be to the satisfaction of IRS. However, it is never to be significantly less than that required by 2.9.3.

2.9.3 At final equilibrium after flooding:

.1 the righting lever curve is to have a minimum range of 20° beyond the position of equilibrium in association with a maximum residual righting lever of at least 0.1 [m] within the 20° range; the area under the curve within this range is not to be less than 0.0175 [m/rad]. Unprotected openings are not to be immersed within this range unless the space concerned is assumed to be flooded. Within this range, the immersion of any of the openings listed in 2.9.2.1 and other openings capable of being closed weathertight may be permitted; and

.2 the emergency source of power is to be capable of operating.

Section 3

Ship Arrangements

3.1 Cargo segregation

3.1.1 Unless expressly provided otherwise, tanks containing cargo or residues of cargo subject to the requirements of this Chapter are to be segregated from accommodation, service and machinery spaces and from drinking water and stores for human consumption by means of a cofferdam, void space, cargo pump-room, pump-room, empty tank, oil fuel tank or other similar space.

3.1.2 Cargo piping is not to pass through any accommodation, service or machinery space other than cargo pump-rooms or pump-rooms.

3.1.3 Cargoes, residues of cargoes or mixtures containing cargoes which react in a hazardous manner with other cargoes, residues or mixtures, are to :

.1 be segregated from such other cargoes by means of a cofferdam, void space, cargo pump-room, pump-room, empty tank, or tank containing a mutually compatible cargo;

.2 have separate pumping and piping systems which are not to pass through other cargo tanks containing such cargoes, unless encased in a tunnel; and

.3 have separate tank venting systems.

3.1.4 If cargo piping systems or cargo ventilation systems are to be separated, this separation may be achieved by the use of design or operational methods. Operational methods shall not be used within a cargo tank and shall consist of one of the following types:

.1 removing spool-pieces or valves and blanking the pipe ends;

.2 arrangement of two spectacle flanges in series, with provisions for detecting leakage into the pipe between the two spectacle flanges.

3.1.5 Cargoes subject to the requirements of this Chapter are not to be carried in either the fore or aft peak tank.

3.2 Accommodation, service and machinery spaces and control stations

3.2.1 No accommodation or service spaces or control stations are to be located within the cargo area except over a cargo pump-room recess or pump-room recess that complies with regulation 11-2/56 of the 1983 SOLAS amendments and no cargo or slop tank is to be aft of the forward end of any accommodation.

3.2.2 In order to guard against the danger of hazardous vapours, due consideration is to be given to the location of air intakes and openings into accommodation, service and machinery spaces and control stations in relation to cargo piping and cargo vent systems.

3.2.3 Entrances, air inlets and openings to accommodation, service and machinery spaces and control stations are not to face the cargo area. They are to be located on the end bulkhead not facing the cargo area and/or on the outboard side of the superstructure or deckhouse at a distance of at least 4% of the length of the ship but not less than 3 [m] from the end of the superstructure or deckhouse facing the cargo area. This distance, however, need not exceed 5 [m]. No doors are to be permitted within the limits mentioned above, except that doors to those spaces not having access to accommodation and service spaces and control stations, such as cargo control stations and store-rooms may be fitted. Where such doors are fitted, the boundaries of the space are to be insulated to "A-60" standard. Bolted plates for removal of machinery may be fitted within the limits specified above. Wheelhouse doors and wheelhouse windows may be located within the limits specified above so long as they are so designed that a rapid and efficient gas and vapour tightening of the wheelhouse can be ensured. Windows and sidescuttles facing the cargo area and on the sides of the superstructures and deckhouses within the limits specified above are to be of the fixed (non-opening) type. Such sidescuttles in the first tier on the main deck are to be fitted with inside covers of steel or equivalent material.

IR3.2.3 Access to forecastle spaces containing sources of ignition may be permitted through doors facing cargo area provided the doors are located outside hazardous areas as defined in IEC Publication 60092-502.

3.3 Cargo pump-rooms

3.3.1 Cargo pump-rooms are to be so arranged as to ensure:

.1 unrestricted passage at all times from any ladder platform and from the floor; and

.2 unrestricted access to all valves necessary for cargo handling for a person wearing the required personnel protective equipment.

3.3.2 Permanent arrangements are to be made for hoisting an injured person with a rescue line while avoiding any projecting obstacles.

3.3.3 Guard railings are to be installed on all ladders and platforms.

3.3.4 Normal access ladders are not to be fitted vertical and are to incorporate platforms at suitable intervals.

3.3.5 Means are to be provided to deal with drainage and any possible leakage from cargo pumps and valves in cargo pump-rooms. The bilge system serving the cargo pump-room is to be operable from outside the cargo pump-room. One or more slop tanks for storage of contaminated bilge water or tank washings are to be provided. A shore-connection with a standard coupling or other facilities are to be provided for transferring contaminated liquids to on-shore reception facilities.

3.3.6 Pump discharge pressure gauges are to be provided outside the cargo pump-room.

3.3.7 Where machinery is driven by shafting passing through a bulkhead or deck, gastight seals with efficient lubrication or other means of ensuring the permanence of the gas seal are to be fitted in way of the bulkhead or deck.

3.4 Access to spaces in the cargo area

3.4.1 Access to cofferdams, ballast tanks, cargo tanks and other spaces in the cargo area is to be direct from the open deck and such as to ensure their complete inspection. Access to double bottom spaces may be through a cargo pump-room, pump-room, deep cofferdam, pipe tunnel or similar compartments, subject to consideration of ventilation aspects.

3.4.2 For access through horizontal openings, hatches or manholes, the dimensions are to be sufficient to allow a person wearing a self-contained air-breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space. The minimum clear opening is to be not less than 600 [mm] by 600 [mm].

3.4.3 For access through vertical openings, or manholes providing passage through the length and breadth of the space, the minimum clear opening is to be not less than 600 [mm] by 800 [mm] at a height of not more than 600 [mm] from the bottom shell plating unless gratings or other footholds are provided.

3.4.4 Smaller dimensions may be approved by IRS in special circumstances, if the ability to traverse such openings or to remove an injured person can be proved to the satisfaction of IRS.

3.5 Bilge and ballast arrangements

3.5.1 Pumps, ballast lines, vent lines and other similar equipment serving permanent ballast tanks are to be independent of similar equipment serving cargo tanks and of cargo tanks themselves. Discharge arrangements for permanent ballast tanks sited immediately adjacent to cargo tanks are to be outside machinery spaces and accommodation spaces. Filling arrangements may be in the machinery spaces provided that such arrangements ensure filling from tank deck level and non-return valves are fitted.

3.5.2 Filling of ballast in cargo tanks may be arranged from deck level by pumps serving permanent ballast tanks, provided that the filling line has no permanent connection to cargo tanks or piping and that non-return valves are fitted.

3.5.3 Bilge pumping arrangements for cargo pump-rooms, pump-rooms, void spaces, slop tanks, double bottom tanks and similar spaces are to be situated entirely within the cargo area except for void spaces, double bottom tanks and ballast tanks where such spaces are separated from tanks containing cargo or residues of cargo by a double bulkhead.

3.6 Pump and pipeline identification

3.6.1 Provisions are to be made for the distinctive marking of pumps, valves and pipelines to identify the service and tanks which they serve.

3.7 Bow or stern loading and unloading arrangements

3.7.1 Cargo piping may be fitted to permit bow or stern loading and unloading. Portable arrangements are not permitted.

3.7.2 Bow or stern loading and unloading lines are not to be used for the transfer of products required to be carried in type 1 ships. Bow and stern loading and unloading lines are not to be used for the transfer of cargoes emitting toxic vapours required to comply with 15.12.1, unless specifically approved by IRS.

3.7.3 In addition to the requirements of 5.1 the following provisions apply :

.1 The piping outside the cargo area is to be fitted at least 760 [mm] inboard on the open deck. Such piping is to be clearly identified and fitted with a shutoff valve at its connection to the cargo piping system within the cargo area. At this location, it is also to be capable of being separated by means of a removable spool piece and blank flanges when not in use.

.2 The shore-connection is to be fitted with a shutoff valve and a blank flange.

.3 The piping is to be full penetration butt welded, and fully radiographed. Flange connections in the piping are only to be permitted within the cargo area and at the shore-connection.

.4 Spray shields are to be provided at the connections specified in .1 as well as collecting trays of sufficient capacity with means for the disposal of drainage.

.5 The piping is to be self-draining to the cargo area and preferably into a cargo tank. Alternative arrangements for draining the piping may be accepted by IRS.

.6 Arrangements are to be made to allow such piping to be purged after use and maintained gas-safe when not in use. The vent pipes connected with the purge are to be located in the cargo area. The relevant connections to the piping are to be provided with shutoff valve and blank flange.

3.7.4 Entrances, air inlets and openings to accommodation, service and machinery spaces and control stations are not to face the cargo shore-connection location of bow or stern loading and unloading arrangements. They are to be located on the outboard side of the superstructure or deckhouse at a distance of at least 4% of the length of the ship but not less than 3 [m] from the end of the house facing the cargo shore-connection location of the bow or stern loading and unloading arrangements. This distance, however, need not exceed 5 [m]. Sidescuttles facing the shore-connection location and on the sides of the superstructure or deckhouse within the distance mentioned above are to be of the fixed (non-opening) type. In addition, during the use of the bow or stern loading and unloading arrangements, all doors, ports and other openings on the corresponding superstructure or deck-house side should be closed. Where, in the case of small ships, compliance with 3.2.3 and this paragraph is not possible, IRS may approve relaxations from the above requirements.

3.7.5 Air pipes and other openings to enclosed spaces not listed in 3.7.4 are to be shielded from any spray which may come from a burst hose or connection.

3.7.6 Escape routes are not to terminate within the coamings required by 3.7.7 or within a distance of 3 [m] beyond the coamings.

3.7.7 Continuous coamings of suitable height are to be fitted to keep any spills on deck and away from the accommodation and service areas.

3.7.8 Electrical equipment within the coamings required by 3.7.6 or within a distance of 3 [m] beyond the coamings is to be in accordance with the requirements of Sec.10.

3.7.9 Fire-fighting arrangements for the bow or stern loading and unloading areas are to be in accordance with 11.3.16.

3.7.10 Means of communication between the cargo control station and the cargo shore-connection location are to be provided and certified safe, if necessary. Provision is to be made for the remote shutdown of cargo pumps from the cargo shore-connection location.

IR3.8 Emergency towing arrangement (ETA)

IR3.8.1 All chemical carriers of deadweight 20,000 tonnes and above are to be provided with emergency towing arrangements at both forward and aft ends. Emergency towing arrangements are to be as per Pt.5, Ch.2, Sec.2.

Section 4

Cargo Containment

4.1 Definitions

4.1.1 **Independent tank** means a cargo containment envelope which is not contiguous with, or part of, the hull structure. An independent tank is built and installed so as to eliminate whenever possible (or in any event to minimize) its stressing as a result of stressing or motion of the adjacent hull structure. An independent tank is not essential to the structural completeness of the ship's hull.

4.1.2 **Integral tank** means a cargo containment envelope which forms part of the ship's hull and which may be stressed in the same manner and by the same loads which stress the contiguous hull structure and which is normally essential to the structural completeness of the ship's hull.

4.1.3 **Gravity tank** means a tank having a design pressure not greater than 0.7 bar gauge at the top of the tank. A gravity tank may be independent or integral. A gravity tank is to be constructed and tested according to recognized standards taking account of the temperature of carriage and relative density of the cargo.

4.1.4 **Pressure tank** means a tank having a design pressure greater than 0.7 bar gauge. A pressure tank is to be an independent tank and is to be of a configuration permitting the application of pressure vessel design criteria according to recognized standards.

4.2 Tank type requirements for individual products

4.2.1 Requirements for both installation and design of tank types for individual products are shown in column "f" in Sec.17, Table 17.1.1.

Section 5

Cargo Transfer

5.1 Piping scantlings

5.1.1 Subject to the requirements of 5.1.4 the wall thickness [t] of pipes is not to be less than:

$$t = \frac{t_o + b + c}{1 - \frac{a}{100}} [mm]$$

where,

t_o = theoretical thickness

t_o = PD/(2Ke+P) [mm]

where,

P = design pressure [MPa] referred to in 5.1.2

D = outside diameter [mm]

K = allowable stress [N/mm^2] referred to in 5.1.5

e = efficiency factor; equal to 1.0 for seamless pipes and for longitudinally or spirally welded pipes delivered by approved manufacturers of welded pipes which are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with recognized standards. In other cases, an efficiency factor of less than 1.0, in accordance with recognized standards may be required depending on the manufacturing process.

b = allowance for bending [mm]. The value of b is to be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b is to be not less than:

$$b = \frac{D\, t_o}{2.5\, r} [mm]$$

where,

r = mean radius of the bend [mm]

c = corrosion allowance [mm]. If corrosion or erosion is expected, the wall thickness of piping is to be increased over that required by the other design requirements

a = negative manufacturing tolerance for thickness (per cent).

5.1.2 The design pressure P in the formula for to in 5.1.1 is the maximum gauge pressure to which the system may be subjected in service, taking into account the highest set pressure on any relief valve on the system.

5.1.3 Piping and piping system components which are not protected by a relief valve, or which may be isolated from their relief valve, are to be designed for at least the greatest of:

.1 piping systems or components which may contain some liquid, the saturated vapour pressure at 45°C;

.2 the pressure setting of the associated pump discharge relief valve;

.3 the maximum possible total pressure head at the outlet of the associated pumps when a pump discharge relief valve is not installed.

5.1.4 The design pressure is not to be less than 1 [MPa] gauge except for open-ended lines where it is to be not less than 0.5 [MPa] gauge.

5.1.5 For pipes, the allowable stress to be considered in the formula for to in 5.1.1 is the lower of the following values:

$$\frac{R_m}{A} \text{ or } \frac{R_e}{B}$$

where,

R_m = specified minimum tensile strength at ambient temperature [N/mm^2]

R_e = specified minimum yield stress at ambient temperature [N/mm^2]. If the stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies.

A and B are to have values of at least

A = 2.7

B = 1.8.

5.1.6.1 The minimum wall thickness is to be in accordance with the recognized standards.

5.1.6.2 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to weight of pipes and content and to superimposed loads from supports, ship deflection or other causes, the wall thickness is to be increased over that required by 5.1.1 or, if this is impracticable or would cause excessive local stresses, these loads are to be reduced, protected against or eliminated by other design methods.

5.1.6.3 Flanges, valves and other fittings are to be in accordance with recognized standards, taking into account the design pressure defined under 5.1.2.

5.1.6.4 For flanges not complying with a standard the dimensions of flanges and associated bolts are to be to the satisfaction of IRS.

5.2 Piping fabrication and joining details

5.2.1 The requirements of this Section apply to piping inside and outside the cargo tanks. However, relaxations from these requirements may be accepted in accordance with recognized standards for open-ended piping and for piping inside cargo tanks except for cargo piping serving other cargo tanks.

5.2.2 Cargo piping is to be joined by welding except:

.1 for approved connections to shutoff valves and expansion joints; and

.2 for other exceptional cases specifically approved by IRS.

5.2.3 The following direct connections of pipe lengths, without flanges may be considered:

.1 Butt welded joints with complete penetration at the root may be used in all applications.

.2 Slip-on welded joints with sleeves and related welding having dimensions in accordance with recognized standards are only to be used for pipes with an external diameter of 50 [mm] or less. This type of joint is not to be used when crevice corrosion is expected to occur.

.3 Screwed connections in accordance with recognized standards are only to be used for accessory lines and instrumentation lines with external diameters of 25 [mm] or less.

5.2.4 Expansion of piping is normally to be allowed for by the provision of expansion loops or bends in the piping system.

.1 Bellows in accordance with recognized standards may be specially considered.

.2 Slip joints are not to be used.

5.2.5 Welding, post weld heat treatment and non-destructive testing are to be performed in accordance with Part 4 of IRS Rules.

5.3 Flange connections

5.3.1 Flanges are to be of the welded neck, slip-on or socket-welded type. However, socket-welded-type flanges are not to be used in nominal size above 50 [mm].

5.3.2 Flanges are to comply with recognized standards as to their type, manufacture and test.

5.4 Test requirements for piping

5.4.1 The test requirements of this Section apply to piping inside and outside cargo tanks. However, relaxations from these requirements may be accepted in accordance with recognized standards for piping inside tanks and open-ended piping.

5.4.2 After assembly, each cargo piping system is to be subject to a hydrostatic test to at least 1.5 times the design pressure. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation aboard the ship. Joints welded on board are to be hydrostatically tested to at least 1.5 times the design pressure.

5.4.3 After assembly on board, each cargo piping system is to be tested for leaks to a pressure depending on the method applied.

5.5 Piping arrangements

5.5.1 Cargo piping is not to be installed under deck between the outboard side of the cargo-containment spaces and the skin of the ship unless clearances required for damage protection (see 2.6) are maintained; but such distances may be reduced where damage to the pipe would not cause release of cargo provided that the clearance required for inspection purposes is maintained.

5.5.2 Cargo piping, located below the main deck, may run from the tank it serves and penetrate tank bulkheads or boundaries common to longitudinally or transversally adjacent cargo tanks, ballast tanks, empty tanks, pump-rooms or cargo pump-rooms provided that inside the tank it serves, it is fitted with a stop valve operable from the weather deck and provided cargo compatibility is assured in the event of piping failure. As an exception, where a cargo tank is adjacent to a cargo pump-room, the stop valve operable from the weather deck may be situated on the tank bulkhead on the cargo pump-room side, provided an additional valve is fitted between the bulkhead valve and the cargo pump. A totally enclosed hydraulically operated valve located outside the cargo tank may, however, be accepted provided that the valve is:

.1 designed to preclude the risk of leakage;

.2 fitted on the bulkhead of the cargo tank which it serves;

.3 suitably protected against mechanical damage;

.4 fitted at a distance from the shell, as required for damage protection; and

.5 operable from the weather deck.

5.5.3 In any cargo pump-room where a pump serves more than one tank, a stop valve is to be fitted in the line to each tank.

5.5.4 Cargo piping installed in pipe tunnels is also to comply with the requirements of 5.5.1 and 5.5.2. Pipe tunnels are to satisfy all tank requirements for construction, location and ventilation and electrical hazard requirements. Cargo compatibility is to be assured in the event of a piping failure. The tunnel is not to have any other openings except to the weather deck and cargo pump-room or pump-room.

5.5.5 Cargo piping passing through bulkheads is to be so arranged as to preclude excessive stresses at the bulkhead and is not to utilize flanges bolted through the bulkhead.

5.6 Cargo transfer control systems

5.6.1 For the purpose of adequately controlling the cargo, cargo transfer systems are to be provided with:

.1 one stop valve capable of being manually operated on each tank filling and discharge line, located near the tank penetration; if an individual deepwell pump is used to discharge the contents of a cargo tank, a stop valve is not required on the discharge line of that tank;

.2 one stop valve at each cargo hose connection;

.3 remote shutdown devices for all cargo pumps and similar equipment.

5.6.2 The controls necessary during transfer or transport of cargoes covered by this Chapter other than in cargo pump-rooms which have been dealt with elsewhere in this Chapter are not to be located below the weather deck.

5.6.3 For certain products additional cargo transfer control requirements are shown in column "o" in Sec.17, Table 17.1.1.

5.7 Ship's cargo hoses

5.7.1 Liquid and vapour hoses used for cargo transfer are to be compatible with the cargo and suitable for the cargo temperature.

5.7.2 Hoses subject to tank pressure or the discharge pressure of pumps are to be designed for a bursting pressure not less than 5 times the maximum pressure the hose will be subjected to during cargo transfer.

5.7.3 Each new type of cargo hose, complete with end fittings, is to be prototype-tested at a normal ambient temperature with 200 pressure cycles from zero to at least twice the specified maximum working pressure. After this cycle pressure test has been carried out, the prototype test is to demonstrate a bursting pressure not less than 5 times its specified maximum working pressure at the intended extreme service temperature. Hoses used for prototype testing are not to be used for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced is to be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure but not more than two-fifths of its bursting pressure. The hose is to be stenciled or otherwise marked with its specified maximum working pressure and, if used in other than ambient temperature services, its maximum and minimum service temperature, as applicable. The specified maximum working pressure is not to be less than 1 [MPa] gauge.

IR5.8 Integrated cargo and ballast system

IR5.8.1 The requirements given in Pt.5, Ch.2, Sec.7.6 are to be applied.

Section 6

Materials of Construction, Protective Linings and Coatings

6.1 Structural materials used for tank construction, together with associated piping, pumps, valves, vents and their jointing materials, are to be suitable at the temperature and pressure for the cargo to be carried in accordance with recognized standards. Steel is assumed to be the normal material of construction.

6.2 The shipyard is responsible for providing compatibility information to the ship operator and/or master. This must be done in a timely manner before delivery of the ship or on completion of a relevant modification of the material of construction.

6.3 Where applicable the following are to be taken into account in selecting the material of construction:

.1 notch ductility at the operating temperature;

.2 corrosive effect of the cargo;

.3 possibility of hazardous reactions between the cargo and the material of construction; and

.4 suitability of linings.

6.4 The shipper of the cargo is responsible for providing compatibility information to the ship operator and/or master. This must be done in a timely manner before transportation of the product. The cargo shall be compatible with all materials of construction such that:

.1 no damage to the integrity of the materials of construction is incurred; and/or

.2 no hazardous, or potentially hazardous reaction is created.

IR 6.5 For use of aluminium coatings onboard chemical tankers also see 1.3.4 & 1.3.5 of Ch.2.

Section 7

Cargo Temperature Control

7.1 General

7.1.1 When provided, any cargo heating or cooling systems are to be constructed, fitted and tested to the satisfaction of IRS. Materials used in the construction of temperature-control systems are to be suitable for use with the product intended to be carried.

7.1.2 Heating or cooling media is to be of a type approved for use with the specific cargo. Consideration is to be given to the surface temperature of heating coils or ducts to avoid dangerous reactions from localized overheating or overcooling of cargo. (See also 15.13.7).

7.1.3 Heating or cooling systems are to be provided with valves to isolate the system for each tank and to allow manual regulation of flow.

7.1.4 In any heating or cooling system, means are to be provided to ensure that, when in any condition other than empty, a higher pressure can be maintained within the system than the maximum pressure head that could be exerted by the cargo-tank contents on the system.

7.1.5 Means are to be provided for measuring the cargo temperature as under:

.1 The means for measuring the cargo temperature are to be of restricted or closed type, respectively, when a restricted or closed gauging device is required for individual substances as shown in column "j" in Sec.17, Table 17.1.1.

.2 A restricted temperature measuring device is subject to the definition for a restricted gauging device in 13.1.1.2, e.g. a portable thermometer lowered inside a gauge tube of the restricted type.

.3 A closed temperature-measuring device is subject to the definition for closed gauging device in 13.1.1.3, e.g. a remote-reading thermometer of which the sensor is installed in the tank.

.4 When overheating or overcooling could result in a dangerous condition, an alarm system which monitors the cargo temperature is to be provided. (See also operational requirements in 16.6).

7.1.6 When products for which 15.12, 15.12.1 or 15.12.3 are listed in column "o" in the table of Sec.17, Table 17.1.1 are being heated or cooled, the heating or cooling medium is to operate in a circuit:

.1 which is independent of other ship's services, except for another cargo heating or cooling system, and which does not enter the machinery space; or

.2 which is external to the tank carrying toxic products; or

.3 where the medium is sampled to check for the presence of cargo before it is recirculated to other services of the ship or into the machinery space. The sampling equipment is to be located within the cargo area and be capable of detecting the presence of any toxic cargo being heated or cooled. Where this method is used, the coil return is to be tested not only at the commencement of heating or cooling or a toxic product, but also on the first occasion the coil is used subsequent to having carried an unheated or uncooled toxic cargo.

7.2 Additional requirements

7.2.1 For certain products, additional requirements contained in Sec.15 are shown in column "o" in Sec.17, Table 17.1.1.

Section 8

Cargo Tank Venting and Gas-freeing Arrangement

8.1 Application

8.1.1 Unless expressly provided otherwise, this section applies to ship's constructed on or after 1 January 1994.

8.1.2 Ship's constructed before 1 January 1994 should comply with the requirements of Chapter 8 of this Code which were inforce prior to the said date.

8.1.3 For the purpose of this regulation, the term "ship constructed" is as defined in regulation II-1/1.3.1 of the 1974 SOLAS convention as amended.

8.1.4 Ships constructed on or after 1 July 1986 but before 1 January 1994 which fully comply with the requirements of the chapter applicable at that time may be regarded as complying with the requirements of regulation II-2/59 of SOLAS 74.

8.1.5 For ships to which the Chapter applies, the requirements of this Section should apply in lieu of SOLAS regulations II-2/4.5.3, 4.5.6 and 16.3.2.

8.1.6 Ships constructed on or after 1 July 1986, but before 1 July 2002 are to comply with the requirements of paragraph 8.3.3 by the date of the first scheduled dry-docking after 1 July 2002, but not later than 1 July 2005. However, IRS may approve relaxation of paragraph 8.3.3 for ships of less than 500 gross tonnage which were constructed on or after 1 July 1986, but before 1 July 2002.

8.2 Cargo tank venting

8.2.1 All cargo tanks are to be provided with a venting system appropriate to the cargo being carried and these systems are to be independent of the air pipes and venting systems of all other compartments of the ship. Tank venting systems are to be designed so as to minimize the possibility of cargo vapour accumulating about the decks, entering accommodation, service and machinery spaces and control stations and in the case of flammable vapours entering or collecting in spaces or areas containing sources of ignition. Tank venting systems are to be arranged to prevent entrance of water into the cargo tanks and at the same time, vent outlets should direct the vapour discharge upwards in the form of unimpeded jets.

8.2.2 The venting systems are to be connected to the top of each cargo tank and as far as practicable the cargo vent lines are to be self-draining back to the cargo tanks under all normal operational conditions of list and trim. Where it is necessary to drain venting systems above the level of any pressure/vacuum valve, capped or plugged drain cocks are to be provided.

8.2.3 Provision is to be made to ensure that the liquid head in any tank does not exceed the design head of that tank. Suitable high-level alarms, overflow control systems or spill valves, together with gauging and tank filling procedures may be accepted for this purpose. Where the means of limiting cargo tank overpressure includes an automatic closing valve, the valve is to comply with the appropriate provisions 15.18.

8.2.4 Tank venting systems are to be designed and operated so as to ensure that neither pressure nor vacuum created in the cargo tanks during loading or unloading exceeds tank design parameters. The main factors to be considered in the sizing of a tank venting system are as follows:

.1 design loading and unloading rate;

.2 gas evolution during loading; this should be taken account of by multiplying the maximum loading rate by a factor of at least 1.25;

.3 density of the cargo vapour mixture;

.4 pressure less in vent piping and across valves and fittings;

.5 pressure/vacuum settings of relief devices.

8.2.5 Tank vent piping connected to cargo tanks of corrosion-resistant material, or to tanks which are lined or coated to handle special cargoes, as required by this Chapter, is to be similarly lined or coated, or constructed of corrosion-resistant material.

8.2.6 The master is to be provided with the maximum permissible loading and unloading rates for each tank or group of tanks consistent with design of the venting systems.

8.3 Types of tank venting systems

8.3.1 **An Open tank venting system** is a system which offers no restriction except for friction losses to the free flow of cargo vapours to and from the cargo tanks during normal operations. An open venting system may consist of individual vents from each tank, or such individual vents may be combined into a common header or headers, with due regard to cargo segregation. In no case should shut-off valves be fitted either to the individual vents or to the header.

8.3.2 **A Controlled tank venting system** is a system in which pressure and vacuum relief valves or pressure/vacuum valves are fitted to each tank to limit the pressure or vacuum in the tank. A controlled venting system may consist of individual vents from each tank or such individual vents on the pressure side only as may be combined into a common header or headers with due regard to cargo segregation. In no case should shut-off valves be fitted either above or below pressure or vacuum relief valves or pressure/vacuum valves. Provision may be made for bypassing a pressure or vacuum valve or pressure/vacuum valve under certain operating conditions provided that the requirements of 8.2.5 is maintained and that there is suitable indication to show whether or not the valve is bypassed.

IR8.3.2 By-passing of high velocity valves is not allowed. In other cases by-passing pressure/vacuum valves may be allowed during cargo operations for cargoes which do not require a vapour return system, provided the vent-line outlet is fitted with flame arrestors and is located at a height above deck level as required by 8.3.4.1.

8.3.3 On ships constructed on or after 1 July 2002, controlled tank venting systems should consist of a primary and a secondary means of allowing full flow relief of vapour to prevent over-pressure or under-pressure in the event of failure of one means. Alternatively, the secondary means may consist of pressure sensors fitted in each tank with a monitoring system in the ship's cargo control room or position from which cargo operations are normally carried out. Such monitoring equipment should also provide an alarm facility which is activated by detection of over-pressure or under-pressure conditions within a tank.

8.3.4 The position of vent outlets of a controlled tank venting system is to be arranged:

.1 at a height of not less than 6 [m] above the weather deck or above a raised walkway if fitted within 4 [m] of the raised walkway;

.2 at a distance of at least 10 [m] measured horizontally from the nearest air intake or opening to accommodation, service and machinery spaces and ignition sources.

8.3.5 The vent outlet height referred to in 8.3.4.1 may be reduced to 3 [m] above the deck or a raised walkway, as applicable, provided that high velocity venting valves of an approved type directing the vapour/air mixture upwards in a unimpeded jet with an exit velocity of at least 30 [m/s] are fitted.

8.3.6 Controlled tank venting systems fitted to tanks to be used for cargoes having a flashpoint not exceeding 60°C (closed cup test) are to be provided with devices to prevent the passage of flame into the cargo tanks. The design, testing and locating of the devices should contain at least the standards adopted by the Organisation.

8.3.7 In designing venting systems and in the selection of devices to prevent the passage of flame for incorporation into the tank venting system, due attention is to be paid to the possibility of the blockage of these systems and fittings by, for example, the freezing of cargo vapour, polymer build up, atmospheric dust or icing up in adverse weather conditions. In this context it is to be noted that flame arresters and flame screens are more susceptible to blockage. Provisions are to be made such that the system and fittings may be inspected, operationally checked, cleaned or renewed as applicable.

8.3.8 Reference in 8.3.1 and 8.3.2 to the use of shut-off valves in the venting lines are to be interpreted to extend to all other means of stoppage including spectacle blanks and blank flanges.

8.4 Venting requirements for individual products

8.4.1 Venting requirements for individual products are shown in column "g" and additional requirements in column "o" in Sec.17, Table 17.1.1.

8.5 Cargo Tank Purging

8.5.1 When the application of inert gas is required by 11.1.1, before gas-freeing, the cargo tanks are to be purged with inert gas through outlet pipes with cross-sectional area such that an exit velocity of at least 20 [m/s] can be maintained when any three tanks are being simultaneously supplied with inert gas. The outlets are to extend not less than 2 [m] above the deck level. Purging is to continue until the concentration of hydrocarbon or other flammable vapours in the cargo tanks has been reduced to less than 2% by volume.

8.6 Cargo tank gas-freeing

8.6.1 The arrangements for gas-freeing cargo tanks used for cargoes other than those for which open venting is permitted are to be such as to minimize the hazards due to the dispersal of flammable or toxic vapours in the atmosphere and to flammable or toxic vapour mixtures in a cargo tank. Accordingly, gas-freeing operations are to be carried out such that vapour is initially discharged:

.1 through the vent outlets specified in 8.3.4 and 8.3.5; or

.2 through outlets at least 2 [m] above the cargo tank deck level with a vertical efflux velocity of at least 30 [m/s] maintained during the gas freeing operation; or

.3 through outlets at least 2 [m] above the cargo tank deck level with a vertical efflux velocity of at least 20 [m/s] which are protected by suitable devices to prevent the passage of flame.

When the flammable vapour concentration at the outlets has been reduced to 30% of the lower flammable limit and in the case of a toxic product the vapour concentration does not present a significant health hazard, gas freeing may thereafter be continued at cargo tank deck level.

8.6.2 The outlets referred to in 8.6.1.2 and 8.6.1.3 may be fixed or portable pipes.

8.6.3 In designing a gas-freeing system in conformity with 8.6.1 particularly in order to achieve the required exit velocities of 8.6.1.2 and 8.6.1.3, due consideration are to be given to the following:

.1 materials of construction of system;

.2 time to gas-free;

.3 flow characteristics of fans to be used;

.4 the pressure losses created by ducting, piping, cargo tank inlets and outlets;

.5 the pressure achievable in the fan driving medium (e.g. water or compressed air);

.6 the densities of the cargo vapour/air mixtures for the range of cargoes to be carried.

Section 9

Environmental Control

9.1 General

IR 9.1.1 The requirements of this Section are not requirements for the maintenance of class.

9.1.1 Vapour spaces within cargo tanks and, in some cases, spaces surrounding cargo tanks may require to have specially controlled atmospheres.

9.1.2 There are four different types of control for cargo tanks, as follows:

.1 **Inerting** by filling the cargo tank and associated piping systems and, where specified in Sec.15, the spaces surrounding the cargo tanks, with a gas or vapour which will not support combustion and which will not react with the cargo, and maintaining that condition.

.2 **Padding** by filling the cargo tank and associated piping systems with a liquid, gas or vapour which separates the cargo from the air, and maintaining that condition.

.3 **Drying** by filling the cargo tank and associated piping systems with moisture-free gas or vapour with a dewpoint of -40°C or below at atmospheric pressure, and maintaining that condition.

.4 **Ventilation** forced or natural.

9.1.3 Where inerting or padding of cargo tanks is required by this Chapter in column ‘h’ of Section 17:

.1 An adequate supply of inert gas for use in filling and discharging the cargo tanks is to be carried or is to be manufactured on board unless a shore supply is available. In addition, sufficient inert gas is to be available on the ship to compensate for normal losses during transportation.

.2 The inert gas system on board the ship is to be able to maintain a pressure of at least 0.07 bar gauge within the containment system at all times. In addition, the inert gas system is not to raise the cargo tank pressure to more than the tank's relief valve setting.

.3 Where padding is used, similar arrangements for supply of the padding medium is to be made as required for inert gas in .1 and .2.

.4 Means are to be provided for monitoring ullage spaces containing a gas blanket to ensure that the correct atmosphere is being maintained.

.5 Inerting or padding arrangements or both, where used with flammable cargoes, are to be such as to minimize the creation of static electricity during the admission of the inerting medium.

9.1.4 Where drying is used and dry nitrogen is used as the medium, similar arrangements for supply of the drying agent are to be made to those required in 9.1.3. Where drying agents are used as the drying medium on all air inlets to the tank, sufficient medium is to be carried for the duration of the voyage, taking into consideration the diurnal temperature range and the expected humidity.

9.2 Environmental control requirements for individual products

9.2.1 The required types of environmental control for certain products are shown in column "h" in Sec.17, Table 17.1.1.

Section 10

Electrical Installations

10.1 General

10.1.1 The provisions of this Section are applicable to ships carrying cargoes which are inherently, or due to their reaction with other substances, flammable or corrosive to the electrical equipment and are to be applied in conjunction with applicable electrical requirements of Part D, Chapter II-1 of SOLAS.

10.1.2.1 Electrical installations are to be such as to minimize the risk of fire and explosion from flammable products.

10.1.2.2 Where the specific cargo is liable to damage the materials normally used in electrical apparatus, due consideration is to be given to the particular characteristics of the materials chosen for conductors, insulation, metal parts, etc. As far as necessary, these components are to be protected to prevent contact with gases or vapours liable to be encountered.

10.1.3 IRS should take appropriate steps to ensure uniformity in the implementation and the application of the provisions of this Section in respect of electrical installations.

10.1.4 Electrical equipment, cables and wiring, is not to be installed in the hazardous locations unless it conforms with the standards not inferior to those acceptable to the Organization*. However, for locations not covered by such standards, electrical equipment, cables and wiring which do not conform to the standards may be installed in hazardous locations based on a risk assessment to the satisfaction of the Administration, to ensure that an equivalent level of safety is assured.

* Reference is made to the recommendations published by the International Electrotechnical Commission, in particular to Publication IEC 60079-1-1 : 2002.

10.1.5 Where electrical equipment is installed in hazardous locations, as permitted in this Section, it is to be to the satisfaction of IRS and of certified type for operation in the flammable atmosphere concerned, as indicated in column "i" in Sec.17, Table 17.1.1.

10.1.6 For guidance, indication is given if the flashpoint of a substance is in excess of 60°C (closed cup test). In the case of heated cargo, carriage conditions might need to be established and the requirements for cargoes having a flashpoint not exceeding 60°C.

10.2 Bonding

Independent cargo tanks are to be electrically bonded to the hull. All gasketed cargo pipe joints and hose connections are to be electrically bonded.

10.3 Electrical requirements for individual products

Electrical requirements for individual products are shown in column "i" in Sec.17, Table 17.1.1.

Section 11

Fire Protection and Extinction

11.1 Application

11.1.1 The requirements for tankers in chapter II-2 of SOLAS would apply to ships covered by this chapter, irrespective of tonnage, including ships of less than 500 tons gross tonnage, except that:

.1 regulations 10.8 and 10.9 do not apply;

.2 regulation 4.5.1.2, i.e. the requirement for location of the main cargo control station, need not apply;

.3 regulations 10.2, 10.4 and 10.5 as applicable to cargo ships are to apply as they would apply to cargo ships of 2,000 tons gross tonnage and over;

.4 regulation 10.5.6 shall apply to ships of 2000 gross tonnage and over;

.5 the provisions of 11.3 are to apply in lieu of regulation 10.8; and

.6 the provisions of 11.2 are to apply in lieu of regulation 10.9.

.7 regulation 4.5.10 shall apply to ships of 500 gross tonnage and over, replacing “hydrocarbon gases” by “flammable vapours” in the regulation; and

.8 regulations 13.3.4 and 13.4.3 shall apply to ships of 500 gross tonnage and over.

IR11.1.1 The following interpretation is to be applied to 11.1.1.3 and 11.1.1.4 above:

a) SOLAS regulations II-2/10.2 and 10.4 apply to cargo ships of 500 gross tonnage and over, under SOLAS and to chemical carriers, regardless of size, under the IBC Code.

b) SOLAS II-2/10.5, except for sub-paragraph 10.5.6, applies to chemical carriers, regardless of size, constructed on/after 1 July 1986.

c) SOLAS II-2/10.5.6 applies only to chemical carriers constructed on/after 1 July 2002 and of 2,000 gt and above.

11.1.2 Notwithstanding the provisions of 11.1.1, ships engaged solely in the carriage of products which are non-flammable (entry NF in column 'i' of the table of minimum requirements) need not comply with requirements for tankers specified in SOLAS Chapter II-2, the requirements for cargo ships of that chapter, except that regulation 10.7 need not apply to such ships and 11.2 and 11.3 hereunder need not apply.

11.1.3 For ships engaged solely in the carriage of products with flashpoint above 60°C (entry "yes" in column 'i' of the table of minimum requirements) requirements of Chapter II-2 of SOLAS may apply as specified in regulation II-2/ 1.6.4 in lieu of the provisions of this Section.

11.1.4 In lieu of the provisions of SOLAS regulation II-2/1.6.7, the requirements of regulations II-2/4.5.10.1.1 and II-2/4.5.10.1.4 shall apply and a system for continuous monitoring of the concentration of flammable vapours shall be fitted on ships of 500 gross tonnage and over which were constructed before 1 January 2009 by the date of the first scheduled dry-docking after 1 January 2009, but not later than 1 January 2012. Sampling points or detector heads should be located in suitable positions in order that potentially dangerous leakages are readily detected. When the flammable vapour concentration reaches a pre-set level which shall not be higher than 10% of the lower flammable limit, a continuous audible and visual alarm signal shall be automatically effected in the pump-room and cargo control room to alert personnel to the potential hazard. However, existing monitoring systems already fitted having a pre-set level not greater than 30% of the lower flammable limit may be accepted. Notwithstanding the above provisions, the Administration may exempt ships not engaged on international voyages from those requirements.

11.2 Cargo pump-rooms

11.2.1 The cargo pump-room of any ship is to be provided with a fixed carbon dioxide fire-extinguishing system as specified in SOLAS regulation II-2/10.9.1.1. A notice is to be exhibited at the controls stating that the system is only to be used for fire-extinguishing and not for inerting purposes, due to the electrostatic ignition hazard. The alarms referred to in regulation (II-2/19.9.1.1.1) of SOLAS amendments are to be safe for use in a flammable cargo vapour-air mixture. For the purpose of this requirement, an extinguishing system is to be provided which would be suitable for machinery spaces. However, the amount of gas carried is to be sufficient to provide a quantity of free gas equal to 45% of the gross volume of the cargo pump-room in all cases.

11.2.2 Cargo pump-rooms of ships which are dedicated to the carriage of a restricted number of cargoes are to be protected by an appropriate fire- extinguishing system approved by IRS.

11.2.3 If cargoes are to be carried which are not suited to extinguishment by carbon dioxide or equivalent media, the cargo pump-room should be protected by a fire extinguishing system consisting of either a fixed pressure water spray or high expansion foam system. The International Certificate of Fitness for the Carriage of Dangerous Chemical in Bulk will reflect this conditional requirement.

11.3 Cargo area

11.3.1 Every ship is to be provided with a fixed deck foam system in accordance with the requirements of 11.3.2 to 11.3.12.

11.3.2 Only one type of foam concentrate is to be supplied, and it is to be effective for the maximum possible number of cargoes intended to be carried. For other cargoes for which foam is not effective or is incompatible, additional arrangements to the satisfaction of IRS are to be provided. Regular protein foams are not to be used.

11.3.3 The arrangements for providing foam are to be capable of delivering foam to the entire cargo tanks deck area as well as into any cargo tank, the deck of which is assumed to be ruptured.

11.3.4 The deck foam system is to be capable of simple and rapid operation. The main control station for the system is to be suitably located outside of the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fires in the area protected.

11.3.5 The rate of supply of foam solution is to be not less than the greatest of the following:

.1 2 [l/min] per square metre of the cargo tanks deck area, where cargo tanks deck area means the maximum breadth of the ship times the total longitudinal extent of the cargo tank spaces;

.2 20 [l/min] per square metre of the horizontal sectional area of the single tank having the largest such area;

.3 10 [l/min] per square metre of the area protected by the largest monitor, such area being entirely forward of the monitor, but not less than 1,250 [l/min]. For ships of less than 4,000 tonnes deadweight, the minimum capacity of the monitor is to be to the satisfaction of IRS.

11.3.6 Sufficient foam concentrate is to be supplied to ensure at least 30 min of foam generation when using the highest of the solution rates stipulated in 11.3.5.1, 11.3.5.2 and 11.3.5.3.

11.3.7 Foam from the fixed foam system is to be supplied by means of monitors and foam applicators. At least 50% of the foam rate required in 11.3.5.1 or 11.3.5.2 is to be delivered from each monitor. The capacity of any monitor is to be at least 10 [l/min] of foam solution per square metre of deck area protected by that monitor, such area being entirely forward of the monitor. Such capacity is to be not less than 1,250 [l/min]. For ships of less than 4,000 tonnes deadweight, the minimum capacity of the monitor is to be to the satisfaction of IRS.

11.3.8 The distance from the monitor to the farthest extremity of the protected area forward of that monitor is to be not more than 75% of the monitor throw in still air conditions.

11.3.9 A monitor and hose connection for a foam applicator is to be situated both port and starboard at the poop front or accommodation spaces facing the cargo area.

11.3.10 Applicators are to be provided for flexibility of action during fire-fighting operations and to cover areas screened from the monitors. The capacity of any applicator is not to be less than 400 [l/min] and the applicator throw in still air conditions is to be not less than 15 [m]. The number of foam applicators provided are to be not less than four. The number and disposition of foam main outlets are to be such that foam from at least two applicators can be directed to any part of the cargo tanks deck area.

11.3.11 Valves are to be provided in the foam main, and in the fire main where this is an integral part of the deck foam system, immediately forward of any monitor position to isolate damaged sections of those mains.

11.3.12 Operation of a deck foam system at its required output is to permit the simultaneous use of the minimum required number of jets of water at the required pressure from the fire main.

11.3.13 Ships which are dedicated to the carriage of a restricted number of cargoes are to be protected by alternative provisions to the satisfaction of IRS when they are just as effective for the products concerned as the deck foam system required for the generality of flammable cargoes.

11.3.14 Suitable portable fire-extinguishing equipment for the products to be carried is to be provided and kept in good operating order.

11.3.15 Where flammable cargoes are to be carried all sources of ignition are to be excluded from hazardous locations referred to in 10.2.

11.3.16 Ships fitted with bow or stern loading and unloading arrangements are to be provided with one additional foam monitor meeting the requirements of 11.3.7 and one additional applicator meeting the requirements of 11.3.10. The additional monitor is to be located to protect the bow or stern loading and unloading arrangements. The area of the cargo line forward or aft of the cargo area is to be protected by the above-mentioned applicator.

11.4 Special requirements

Fire-extinguishing media considered to be suitable for certain products are listed for information in column "l" in Sec.17, Table 17.1.1.

Section 12

Mechanical Ventilation in the Cargo Area

12.0 For ships to which the Code applies, the requirements of this Section replace the requirements of SOLAS regulation II-2/4.5.2.6 and 4.5.4. However, for products addressed under paragraphs 11.1.2 and 11.1.3, except acids and products for which paragraph 15.16 apply, SOLAS regulation II-2/4.5.2.6 and 4.5.4 may apply in lieu of the provisions of this Section.

12.1 Spaces normally entered during cargo handling operation

12.1.1 Cargo pump-rooms and other enclosed spaces which contain cargo handling equipment and similar spaces in which work is performed on the cargo are to be fitted with mechanical ventilation systems, capable of being controlled from outside such spaces.

12.1.2 Provision is to be made to ventilate such spaces prior to entering the compartment and operating the equipment and a warning notice requiring the use of such ventilation is to be placed outside the compartment.

12.1.3 Mechanical ventilation inlets and outlets are to be arranged to ensure sufficient air movement through the space to avoid the accumulation of toxic or flammable vapours or both (taking into account their vapour densities) and to ensure sufficient oxygen to provide a safe working environment, but in no case is the ventilation system to have a capacity of less than 30 changes of air per hour based upon the total volume of the space. For certain products, increased ventilation rates for cargo pump-rooms are prescribed in 15.17.

12.1.4 Ventilation systems are to be permanent and are normally to be of the extraction type. Extraction from above and below the floor plates is to be possible. In rooms housing motors driving cargo pumps, the ventilation is to be of the positive pressure type.

12.1.5 Ventilation exhaust ducts from spaces within the cargo area is to discharge upwards in locations at least 10 [m] in the horizontal direction from ventilation intakes and openings to accommodation, service and machinery spaces and control stations and other spaces outside the cargo area.

12.1.6 Ventilation intakes are to be so arranged as to minimize the possibility of recycling hazardous vapours from any ventilation discharge opening.

12.1.7 Ventilation ducts are not to be led through accommodation, service and machinery spaces or other similar spaces.

12.1.8 Electric motors driving fans are to be placed outside the ventilation ducts if the carriage of flammable products is intended. Ventilation fans and fan ducts, in way of fans only, for hazardous locations referred to in Sec.10 are to be of non-sparking construction whose details are given in Pt.5, Ch.2, Sec.6.5 of these Rules.

12.1.9 Sufficient spare parts are to be carried for each type of fan on board, required by this Section.

12.2 Pump-rooms and other enclosed spaces normally entered

Pump-rooms and other enclosed spaces normally entered, which are not covered by 12.1.1, are to be fitted with mechanical ventilation systems, capable of being controlled from outside such spaces and complying with the requirements of 12.1.3, except that the capacity is not to be less than 20 changes of air per hour, based upon the total volume of the space. Provision is to be made to ventilate such spaces prior to entering.

12.3 Spaces not normally entered

Double bottoms, cofferdams, duct keels, pipe tunnels, hold spaces and other spaces where cargo may accumulate, are to be capable of being ventilated to ensure a safe environment when entry into the spaces is necessary. Where a permanent ventilation system is not provided for such spaces, approved means of portable mechanical ventilation are to be provided. Where necessary, owing to the arrangement of spaces, for instance hold spaces, essential ducting for such ventilation is to be permanently installed. For permanent installations, the capacity of eight air changes per hour is to be provided and for portable systems the capacity of 16 air changes per hour. Fans or blowers are to be clear of personnel access openings, and are to comply with 12.1.8.

Section 13

Instrumentation

13.1 Gauging

13.1.1 Cargo tanks are to be fitted with one of the following types of gauging devices:

.1 Open device which makes use of an opening in the tanks and may expose the gauges to the cargo or its vapour. An example of this is the ullage opening.

.2 Restricted device which penetrates the tank and which, when in use, permits a small quantity of cargo vapour or liquid to be exposed to the atmosphere. When not in use, the device is completely closed. The design is to ensure that no dangerous escape of tank contents (liquid or spray) can take place in opening the device.

IR.2 A restricted device could be a sounding pipe with vapour tight cover.

.3 Closed device which penetrates the tank, but which is part of a closed system and keeps tank contents from being released. Examples are the float-type systems, electronic probe, magnetic probe and protected sight glass. Alternatively an indirect device which does not penetrate the tank shell and which is independent of the tank may be used. Examples are weighing of cargo, pipe flow meter, etc.

13.1.2 Gauging devices are to be independent of the equipment required under 15.19.

13.1.3 Open gauging and restricted gauging are to be allowed only where:

.1 open venting is allowed by this Chapter; or

.2 means are provided for relieving tank pressure before the gauge is operated.

13.1.4 Types of gauging for individual products are shown in column "j" in Sec.17, Table 17.1.1.

IR13.1.5 Openings for open and restricted devices are to be located on the weather deck and are not to be arranged in enclosed compartments.

13.2 Vapour detection

13.2.1 Ships carrying toxic or flammable products or both are to be equipped with at least two instruments designed and calibrated for testing for the specific vapours in question. If such instruments are not capable of testing for both toxic concentrations and flammable concentrations, then two separate sets of instruments are to be provided.

13.2.2 Vapour detection instruments may be portable or fixed. If a fixed system is installed, at least one portable instrument is to be provided.

The installation requirements for analysing units are given in Pt.5, Ch.2, Sec.6, Cl.6.4.4 of these Rules.

13.2.3 When toxic-vapour detection equipment is not available for some products which require such detection, as indicated in column "l" in Sec.17, Table 17.1.1. IRS may exempt the ship from the requirement, provided an appropriate entry is made in the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk. When granting such an exemption, the Administration should recognize the necessity for additional breathing-air supply and an entry should be made on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk drawing attention to the provisions of 14.2.4 and 16.4.2.2.

13.2.4 Vapour detection requirements for individual products are shown in column "k" in Sec.17, Table 17.1.1.

Section 14

Personnel Protection

14.1 Protective equipment

IR 14.1.1 The requirements of this Section are not requirements for the maintenance of class.

14.1.1 For the protection of crew members who are engaged in loading and discharging operations, the ship is to have on board suitable protective equipment consisting of large aprons, special gloves with long sleeves, suitable footwear, coveralls of chemical-resistant material, and tight-fitting goggles or face shields or both. The protective clothing and equipment is to cover all skin so that no part of the body is unprotected.

14.1.2 Work clothes and protective equipment are to be kept in easily accessible places and in special lockers. Such equipment is not to be kept within accommodation spaces, with the exception of new, unused equipment and equipment which has not been used since undergoing a thorough cleaning process. IRS may, however, approve storage rooms for such equipment within accommodation spaces if adequately segregated from living spaces such as cabins, passageways, dining rooms, bathrooms, etc.

14.1.3 Protective equipment is to be used in any operation which may entail danger to personnel.

14.2 Safety equipment

14.2.1 Ships carrying cargoes for which 15.12, 15.12.1 or 15.12.3 is listed in column "o" in Sec.17, Table 17.1.1 are to have on board sufficient but not less than three complete sets of safety equipment each permitting personnel to enter a gas-filled compartment and perform work there for at least 20 min. Such equipment is to be in addition to that required by SOLAS regulation II-2/10.10.

14.2.2 One complete set of safety equipment is to consist of:

.1 one self-contained air-breathing apparatus (not using stored oxygen);

.2 protective clothing, boots, gloves and tight-fitting goggles;

.3 fire proof lifeline with belt resistant to the cargoes carried; and

.4 explosion-proof lamp.

14.2.3 For the safety equipment required in 14.2.1, all ships are to carry the following, either:

.1 one set of fully charged spare air bottles for each breathing apparatus;

.2 a special air compressor suitable for the supply of high-pressure air of the required purity;

.3 a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus; or

.4 fully charged spare air bottles with a total free air capacity of at least 6,000 l for each breathing apparatus on board in excess of the requirements of SOLAS Regulation II-2/10.10.

14.2.4 A cargo pump-room on ships carrying cargoes which are subject to the requirements of 15.18 or cargoes for which in column "k" in Sec.17, Table 17.1.1 toxic vapour detection equipment is required but is not available is to have either:

.1 a low-pressure line system with hose connections suitable for use with the breathing apparatus required by 14.2.1. This system is to provide sufficient high-pressure air capacity to supply, through pressure reduction devices, enough low-pressure air to enable two men to work in a gas-dangerous space for at least 1 hour without using the air bottles of the breathing apparatus. Means should be provided for recharging the fixed air bottles and breathing apparatus air bottles from a special air compressor suitable for the supply of high-pressure air of the required purity; or

.2 an equivalent quantity of spare bottled air in lieu of the low-pressure air line.

14.2.5 At least one set of safety equipment as required by 14.2.2 is to be kept in a suitable clearly marked locker in a readily accessible place near the cargo pump-room. The other sets of safety equipment are also to be kept in suitable, clearly marked, easily accessible, places.

14.2.6 The breathing apparatus is to be inspected at least once a month by a responsible officer, and the inspection recorded in the ship's log-book. The equipment is to be inspected and tested by an expert at least once a year.

14.3 Emergency equipment

14.3.1 Ships carrying cargoes, for which 'Yes' is indicated in column 'n' of Table 17.1.1 are to be provided with suitable respiratory and eye protection sufficient for every person on board for emergency escape purposes, subject to the following:

.1 filter-type respiratory protection is unacceptable;

.2 self-contained breathing apparatus is normally to have at least a duration of service of 15 min;

.3 emergency escape respiratory protection is not to be used for fire-fighting or cargo handling purposes and is to be marked to that effect.

Individual cargoes to which the provisions of this paragraph apply are indicated in column "n" in Sec.17, Table 17.1.1.

14.3.2 The ship is to have on board medical first-aid equipment including oxygen resuscitation equipment and antidotes for cargoes carried, based on the guidelines developed by the Organisation.

Reference is made to the Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG), which provides advice on the treatment of casualties in accordance with the symptoms exhibited as well as equipment and antidotes that may be appropriate for treating the casualty.

14.3.3 A stretcher which is suitable for hoisting an injured person up from spaces such as the cargo pump-room is to be placed in a readily accessible location.

14.3.4 Suitably marked decontamination showers and an eyewash are to be available on deck in convenient locations. The showers and eyewash are to be operation in all ambient conditions.

Section 15

Special Requirements

15.1 General

15.1.1 The provisions of this Section are applicable where specific reference is made in column "o" in Sec.17, Table 17.1.1. These requirements are additional to the general requirements of this Chapter.

15.2 Ammonium nitrate solution (93% or less)

15.2.1 The ammonium nitrate solution is to contain at least 7% by weight of water. The acidity (pH) of the cargo when diluted with ten parts of water to one part of cargo by weight is to be between 5.0 and 7.0. The solution is to not contain more than 10 ppm chloride ions, 10 ppm ferric ions, and is to be free of other contaminants.

15.2.2 Tanks and equipment for ammonium nitrate solution are to independent of tanks and equipment containing other cargoes or combustible products. Equipment which may, in service or when defective, release combustible products into the cargo, e.g. lubricants, is not to be used. Tanks are not to be used for seawater ballast.

15.2.3 Except where expressly approved by IRS, ammonium nitrate solutions are not to be transported in tanks which have previously contained other cargoes unless tanks and associated equipment have been cleaned to the satisfaction of IRS.

15.2.4 The temperature of the heat exchanging medium in the tank heating system is not to exceed 160°C. The heating system is to be provided with a control system to keep the cargo at a bulk mean temperature of 140°C. High-temperature alarms at 145°C and 150°C and a low-temperature alarm at 125°C are to be provided. Where the temperature of the heat exchanging medium exceeds 160°C an alarm is also to be given. Temperature alarms and controls are to be located on the navigating bridge.

15.2.5 If the bulk mean cargo temperature reaches 145°C, a cargo sample is to be diluted with ten parts of distilled or demineralized water to one part of cargo by weight and the acidity (pH) is to be determined by means of a narrow range indicator paper or stick. Acidity (pH) measurements is then to be taken every 24 hours. If the acidity (pH) is found to be below 4.2, ammonia gas is to be injected into the cargo until the acidity (pH) of 5.0 is reached.

15.2.6 A fixed installation is to be provided to inject ammonia gas into the cargo. Controls for this system are to be located on the navigation bridge. For this purpose, 300 kg of ammonia per 1,000 tonnes of ammonium nitrate solution is to be available on board.

15.2.7 Cargo pumps are to be of the centrifugal deepwell type or of the centrifugal type with water flushed seals.

15.2.8 Vent piping is to be fitted with approved weatherhoods to prevent clogging. Such weatherhoods are to be accessible for inspection and cleaning.

15.2.9 Hot work on tanks, piping and equipment which have been in contact with ammonium nitrate solution is only to be done after all traces of ammonium nitrate have been removed, inside as well as outside.

15.3 Carbon disulphide

Carbon disulphide may be carried either under a water pad or under a suitable inert gas pad as specified in the following paragraphs:

Carriage under water pad

15.3.1 Provision is to be made to maintain a water pad in the cargo tank during loading, unloading and transit. In addition, a suitable inert gas pad is to be maintained in the ullage space during transit.

15.3.2 All openings are to be in the top of the tank, above the deck.

15.3.3 Loading lines are to terminate near the bottom of the tank.

15.3.4 A standard ullage opening is to be provided for emergency sounding.

15.3.5 Cargo piping and vent lines are to be independent of piping and vent lines used for other cargo.

15.3.6 Pumps may be used for discharging cargo, provided they are of the deepwell or hydraulically driven submersible types. The means of driving a deepwell pump are not to present a source of ignition for carbon disulphide and are not to employ equipment that may exceed a temperature of 80°C.

15.3.7 If a cargo discharge pump is used, it is to be inserted through a cylindrical well extending from the tank top to a point near the tank bottom. A water pad should be formed in this well before attempting pump removal unless the tank has been certified as gas-free.

15.3.8 Water or inert gas displacement may be used for discharging cargo, provided the cargo system is designed for the expected pressure and temperature.

15.3.9 Safety relief valves are to be of stainless steel construction.

15.3.10 Because of its low ignition temperature and close clearances required to arrest its flame propagation, only intrinsically safe systems and circuits are permitted in the hazardous locations described in Sec.10, Cl.10.2.3.

Carriage under suitable inert gas pad

15.3.11 Carbon disulphide is to be carried in independent tanks with a design pressure of not less than 0.06 MPa gauge

15.3.12 All openings are to be located on the top of the tank, above the deck.

15.3.13 Gaskets used in the containment system are to be of a material which does not react with, or dissolve in, carbon disulphide.

15.3.14 Threaded joints are not permitted in the cargo containment system, including the vapour lines.

15.3.15 Prior to loading, the tank(s) is to be inerted with suitable inert gas until the oxygen level is 2% by volume or lower. Means are to be provided to automatically maintain a positive pressure in the tank using suitable inert gas during loading, transport and discharge. The system is to be able to maintain this positive pressure between 0.01 and 0.02 MPa and is to be remotely monitored and fitted with over/under-pressure alarms.

15.3.16 Hold spaces surrounding an independent tank carrying carbon disulphide is to be inerted by a suitable inert gas until the oxygen level is 2% or less. Means are to be provided to monitor and maintain this condition throughout the voyage. Means is also to be provided to sample these spaces for carbon disulphide vapour.

15.3.17 Carbon disulphide is to be loaded, transported and discharged in such a manner that venting to the atmosphere does not occur. If carbon disulphide vapour is returned to shore during loading or to the ship during discharge, the vapour return system is to be independent of all other containment systems.

15.3.18 Carbon disulphide is to be discharged only by submerged deepwell pumps or by a suitable inert gas displacement. The submerged deepwell pumps are to be operated in a way that prevents heat build-up in the pump. The pump is also to be equipped with a temperature sensor in the pump housing with remote readout and alarm in the cargo control room. The alarm is to be set at 80°C. The pump is also to be fitted with an automatic shut-down device, if the tank pressure falls below atmospheric pressure during the discharge.

15.3.19 Air is not to be allowed to enter the cargo tank, cargo pump or lines while carbon disulphide is contained in the system.

15.3.20 No other cargo handling, tank cleaning or deballasting is to take place concurrent with loading or discharge of carbon disulphide.

15.3.21 A water spray system of sufficient capacity is to be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling and the tank domes. The arrangement of piping and nozzles is to be such as to give a uniform distribution rate of 10 $l/m^2/min$. Remote manual operation is to be arranged such that remote starting of pumps supplying the water-spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected. The water-spray system is to be capable of both local and remote manual operation and the arrangement is to ensure that any spilled cargo is washed away. Additionally, a water hose with pressure to the nozzle when atmospheric temperature permits is to be connected ready for immediate use during loading and unloading operations.

15.3.22 No cargo tanks are to be more than 98% liquid-full at the reference temperature (R).

15.3.23 The maximum volume (V_L) of cargo to be loaded in a tank is to be:

$$V_L = 0.98\, V \frac{\rho_R}{\rho_L}$$

where,

V = volume of the tank

ρ_R = relative density of cargo at the reference temperature (R)

ρ_L = relative density of cargo at the loading temperature

R = reference temperature.

15.3.24 The maximum allowable tank filling limits for each cargo tank is to be indicated for each loading temperature which may be applied and for the applicable maximum reference temperature, on a list approved by the Administration. A copy of the list is to be permanently kept on board by the master.

15.3.25 Zones on open deck, or semi-enclosed spaces on open deck within three metres of a tank outlet, gas or vapour outlet, cargo pipe flange or cargo valve of a tank certified to carry carbon disulphide, are to comply with the electrical equipment requirements specified for carbon disulphide in column "i", of Section 17. Also, within the specified zone, no other heat sources, like steam piping with surface temperatures in excess of 80°C is to be allowed.

15.3.26 Means are to be provided to ullage and sample the cargo without opening the tank or disturbing the positive suitable inert gas blanket.

15.3.27 The product is to be transported only in accordance with a cargo handling plan that has been approved by the Administration. Cargo handling plans are to show the entire cargo piping system. A copy of the approved cargo handling plan is to be made available on board. The International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk is to be endorsed to include reference to the approved cargo handling plan.

15.4 Diethyl ether

15.4.1 Unless inerted, natural ventilation is to be provided for the voids around the cargo tanks while the vessel is under way. If a mechanical ventilation system is installed, all blowers are to be of nonsparking construction. Mechanical ventilation equipment is not to be located in the void spaces surrounding the cargo tanks.

15.4.2 Pressure relief valve settings are not to be less than 0.02 MPa gauge for gravity tanks.

15.4.3 Inert gas displacement may be used for discharging cargo from pressure tanks provided the cargo system is designed for the expected pressure.

15.4.4 In view of the fire hazard, provision is to be made to avoid any ignition source or heat generation or both in the cargo area.

15.4.5 Pumps may be used for discharging cargo, provided that they are of a type designed to avoid liquid pressure against the shaft gland or are of a hydraulically operated submerged type and are suitable for use with the cargo.

15.4.6 Provisions are to be made to maintain the inert-gas pad in the cargo tank during loading, unloading and transit.

15.5 Hydrogen peroxide solutions

15.5.1 Hydrogen peroxide solutions over 60% but not over 70%.

15.5.1.1 Hydrogen peroxide solutions over 60% but not over 70% is to be carried in dedicated ships only and no other cargoes are to be carried.

15.5.1.2 Cargo tanks and associated equipment are to be either pure aluminium (99.5%) or solid stainless steel (304L, 316, 316L or 316Ti), and passivated in accordance with approved procedures. Aluminium is not to be used for piping on deck. All nonmetallic materials of construction for the containment system are neither to be attacked by hydrogen peroxide nor contribute to its decomposition.

15.5.1.3 Pump-rooms are not to be used for cargo transfer operations.

15.5.1.4 Cargo tanks are to be separated by cofferdams from oil fuel tanks or any other space containing flammable or combustible materials.

15.5.1.5 Tanks intended for the carriage of hydrogen peroxide are not to be used for seawater ballast.

15.5.1.6 Temperature sensors are to be installed at the top and bottom of the tank. Remote temperature readouts and continuous monitoring are to be located on the navigating bridge. If the temperature in the tanks rises above 35°C, visible and audible alarms are to be activated on the navigation bridge.

15.5.1.7 Fixed oxygen monitors (or gas-sampling lines) are to be provided in void spaces adjacent to tanks to detect leakage of the cargo into these spaces. Remote readouts, continuous monitoring (if gas sampling lines are used, intermittent sampling is satisfactory) and visible and audible alarms similar to those for the temperature sensors are also to be located on the navigating bridge. The visible and audible alarms are to be activated if the oxygen concentration in these void spaces exceeds 30% by volume. Two portable oxygen monitors are also to be available as back-up systems.

15.5.1.8 As a safeguard against uncontrolled decomposition, a cargo jettisoning system is to be installed to discharge the cargo overboard. The cargo is to be jettisoned if the temperature rise of the cargo exceeds a rate of 2°C per hour over a 5 hour period or when the temperature in the tank exceeds 40°C.

15.5.1.9 Cargo tank venting system is to have pressure/vacuum relief valves for normal controlled venting, and rupture discs or a similar device for emergency venting, if tank pressure rises rapidly as a result of uncontrolled decomposition. Rupture discs are to be sized on the basis of tank design pressure, tank size and anticipated decomposition rate.

15.5.1.10 A fixed water-spray system is to be provided for diluting and washing away any concentrated hydrogen peroxide solution spilled on deck. The areas covered by the water-spray are to include the manifold/hose connections and the tank tops of those tanks designated for carrying hydrogen peroxide solutions. The minimum application rate is to satisfy the following criteria:

.1 The product is to be diluted from the original concentration to 35% by weight within 5 minutes of the spill.

.2 The rate and estimated size of the spill is to be based upon maximum anticipated loading and discharge rates, the time required to stop flow of cargo in the event of tank overfill or a piping/hose failure, and the time necessary to begin application of dilution water with actuation at the cargo control location or on the navigating bridge.

15.5.1.11 Only those hydrogen peroxide solutions which have a maximum decomposition rate of 1% per year at 25°C are to be carried. Certification from the shipper that the product meets this standard is to be presented to the master and kept on board. A technical representative of the manufacturer is to be on board to monitor the transfer operations and have the capability to test the stability of the hydrogen peroxide. He is to certify to the master that the cargo has been loaded in a stable condition.

15.5.1.12 Protective clothing that is resistant to hydrogen peroxide solutions is to be provided for each crew member involved in cargo transfer operations. Protective clothing is to include non flammable coveralls, suitable gloves, boots and eye protection.

15.5.2 Hydrogen peroxide solutions over 8% but not over 60% by mass

15.5.2.1 The ship's shell plating is not to form any boundaries of tanks containing this product.

15.5.2.2 Hydrogen peroxide is to be carried in tanks thoroughly and effectively cleaned of all traces of previous cargoes and their vapours or ballast. Procedures for inspection, cleaning, passivation and loading of tanks are to be in accordance with the MSC/Circ.394. A certificate is to be on board the vessel indicating that the procedures in the circular have been followed. The passivation requirement may be waived by an Administration for domestic shipments of short duration. Particular care in this respect is essential to ensure the safe carriage of hydrogen peroxide.

.1 When hydrogen peroxide is carried no other cargoes are to be carried simultaneously.

.2 Tanks which have contained hydrogen peroxide may be used for other cargoes after cleaning in accordance with the procedures outlined in MSC/Circ.394.

.3 Consideration in design is to provide minimum internal tank structure, free draining, no entrapment and ease of visual inspection.

15.5.2.3 Cargo tanks and associated equipment is to be either pure aluminium (99.5%) or solid stainless steel of types suitable for use with hydrogen peroxide (e.g.304, 304L, 316, 316L, 316Ti). Aluminium is not to be used for piping on deck. All nonmetallic materials of construction for the containment system are neither be attacked by hydrogen peroxide nor contribute to its decomposition.

15.5.2.4 Cargo tanks are to be separated by a cofferdam from fuel oil tanks or any other space containing materials incompatible with hydrogen peroxide.

15.5.2.5 Temperature sensors are to be installed at the top and bottom of the tank. Remote temperature readouts and continuous monitoring are to be located on the navigating bridge. If the temperature in the tank rises above 35°C, visible and audible alarms are to activate on the navigating bridge.

15.5.2.6 Fixed oxygen monitors (or gas sampling lines) are to be provided in void spaces adjacent to tanks to detect leakage of the cargo into these spaces. The enhancement of flammability by oxygen enrichments is to be recognized. Remote readouts, continuous monitoring (if gas sampling lines are used, intermittent sampling is satisfactory) and visible and audible alarms similar to those for the temperature sensors are also to be located on the navigating bridge. The visible and audible alarms are to activate if the oxygen concentration in these void spaces exceeds 30% by volume. Two portable oxygen monitors are also to be available as back-up systems.

15.5.2.7 As a safeguard against uncontrolled decomposition, a cargo jettisoning system is to be installed to discharge the cargo overboard. The cargo is to be jettisoned if the temperature rise of the cargo exceeds a rate of 2°C per hour over a 5 hour period or when the temperature in the tank exceeds 40°C.

15.5.2.8 Cargo-tank venting systems with filtration are to have pressure vacuum-relief valves for normal controlled venting, and a device for emergency venting, if tank pressure rises rapidly as a result of an uncontrolled decomposition rate, as stipulated in 15.5.20. These venting systems are to be designed in such a manner that there is no introduction of seawater into the cargo tank even under heavy sea conditions. Emergency venting is to be sized on the basis of tank design pressure and tank size.

15.5.2.9 A fixed water-spray system is to be provided for diluting and washing away any concentrated solution spilled on deck. The areas covered by the water-spray are to include the manifold/hose connections and the tank tops of those tanks designated for the carriage of hydrogen peroxide solutions. The minimum application rate is to satisfy the following criteria:

.1 The product is to be diluted from the original concentration to 35% by weight within 5 minutes of the spill.

.2 The rate of estimated size of the spill is to be based upon maximum anticipated loading and discharge rates, the time required to stop flow of the cargo in the event of tank overfill or a piping/hose failure, and the time necessary to begin application of dilution water with actuation at the cargo control location or on the navigating bridge.

15.5.2.10 Only those hydrogen peroxide solutions which have maximum decomposition rate of 1% per year at 25°C are to be carried. Certification from the shipper that the product meets this standards is to be presented to the master and kept on board. A technical representative of the manufacturer is to be on board to monitor the transfer operations and have the capability to test the stability of the hydrogen peroxide. He is to certify to the master that the cargo has been loaded in a stable condition.

15.5.2.11 Protective clothing that is resistant to hydrogen peroxide is to be provided for each crew member involved in cargo-transfer operations. Protective clothing is to include coveralls that are nonflammable, suitable gloves, boots and eye protection.

15.5.2.12 During transfer of hydrogen peroxide the related piping system is to be separated from all other systems. Cargo hoses used for transfer of hydrogen peroxide are to be marked "For Hydrogen Peroxide Transfer only".

15.5.3 Procedures for inspection, cleaning, passivation and loading of tanks for the carriage of hydrogen peroxide solutions over 8% but not over 60% by mass, which have contained other cargoes, or for the carriage of other cargoes after the carriage of hydrogen peroxide

15.5.3.1 Tanks having contained cargoes other than hydrogen peroxide are to be inspected, cleaned and passivated before re-use for the transport of hydrogen peroxide solutions. The procedures for inspection and cleaning, as given in paragraphs 15.5.3.2 to 15.5.3.8 below, apply to both stainless steel and pure aluminium tanks (see paragraph 15.5.3.2). Procedures for passivation are given in paragraph 15.5.3.9 for stainless steel and 15.5.3.10 for aluminium. Unless otherwise specified, all steps apply to the tanks and to all associated equipment having been in contact with the other cargo.

15.5.3.2 After unloading the previous cargo the tank should be rendered safe and inspected for any residues, scale and rust.

15.5.3.3 Tanks and associated equipment shall be washed with clean filtered water. The water to be used shall at least have the quality of potable water with a low chlorine content.

15.5.3.4 Trace residues and vapours of the previous cargo shall be removed by steaming of tank and equipment.

15.5.3.5 Tanks and equipment are washed again with clean water (quality as above) and dried, using filtered, oil-free air.

15.5.3.6 The atmosphere in the tanks shall be sampled and investigated for the presence of organic vapours and oxygen concentration.

15.5.3.7 The tank shall be checked again by visual inspection for residues of the previous cargo, scale and rust as well as for any smell of the previous cargo.

15.5.3.8 If inspection or measurements indicate the presence of residues of the previous cargo or its vapours, actions described in paragraphs 15.5.3.3 to 15.5.3.5 shall be repeated.

15.5.3.9 Tanks and equipment made from stainless steel have contained other cargoes than hydrogen peroxide or which have been under repair shall be cleaned and passivated, regardless of any previous passivation, according to the following procedure:

.1 New welds and other repaired parts shall be cleaned and finished using stainless steel wire brush, chisel, sandpaper or buff. Rough surfaces shall be given a smooth finish. A final polishing is necessary.

.2 Fatty and oily residues shall be removed by the use of appropriate organic solvents or detergent solutions in water. The use of chlorine-containing compounds shall be avoided as they can seriously interfere with passivation.

.3 The residues of the degreasing agent shall be removed, followed by a washing with water.

.4 In the next step, scale and rust shall be removed by the application of acid (e.g. a mixture of nitric and hydrofluoric acids), followed again by a washing with clean water.

.5 All the metal surfaces which can come into contact with hydrogen peroxide shall be passivated by the application of nitric acid of a concentration between 10 and 35% by mass. The nitric acid must be free from heavy metals, other oxidizing agents or hydrogen fluoride. The passivation process shall continue for 8 to 24 h, depending upon the concentration of acid, the ambient temperature and other factors. During this time a continuous contact between the surfaces to be passivated and the nitric acid shall be ensured. In the case of large surfaces this may be achieved by recirculating the acid. Hydrogen gas may be evolved in the passivation process, leading to the presence of an explosive atmosphere in the tanks. Therefore, appropriate measures must be taken to avoid the build-up or the ignition of such an atmosphere.

.6 After passivation the surfaces shall be thoroughly washed with clean filtered water. The washing process shall be repeated until the effluent water has the same pH value as the incoming water.

.7 Surfaces treated according to the above steps may cause some decomposition when coming into contact with hydrogen peroxide for the first time. This decomposition will cease after a short time (usually within two or three days). Therefore an additional flushing with hydrogen peroxide for a period of at least two days is recommended.

.8 Only degreasing agents and acid cleaning agents which have been recommended for this purpose by the manufacturer of the hydrogen peroxide shall be used in the process.

15.5.3.10 Tanks and equipment made from aluminium and which have contained cargoes other than hydrogen peroxide, or which have been under repair, shall be cleaned and passivated. The following is an example of a recommended procedure:

.1 The tank shall be washed with a solution of a sulphonated detergent in hot water, followed by a washing with water.

.2 The surface shall then be treated for 15 to 20 min with a solution of sodium hydroxide of a concentration of 7% by mass or treated for a longer period with a less concentrated solution (e.g. for 12 h with 0.4 to 0.5% sodium hydroxide). To prevent excessive corrosion at the bottom of the tank when treating with more concentrated solutions of sodium hydroxide, water shall be added continuously to dilute the sodium hydroxide solution which collects there.

.3 The tank shall be thoroughly washed with clean, filtered water. As soon as possible after washing, the surface shall be passivated by the application of nitric acid of a concentration between 30 and 35% by mass. The passivation process shall continue for 16 to 24 h. During this time a continuous contact between the surfaces to be passivated and the nitric acid shall be ensured.

.4 After passivation the surfaces shall be thoroughly washed with clean, filtered water. The washing process shall be repeated until the effluent water has the same pH value as the incoming water.

.5 A visual inspection shall be made to ensure that all surfaces have been treated. It is recommended that an additional flushing is carried out for a minimum of 24 h with dilute hydrogen peroxide solution of a concentration approximately 3% by mass.

15.5.3.11 The concentration and stability of the hydrogen peroxide solution to be loaded shall be determined.

15.5.3.12 The hydrogen peroxide is loaded under intermittent visual supervision of the interior of the tank from an appropriate opening.

15.5.3.13 If substantial bubbling is observed which does not disappear within 15 min after the completion of loading, the contents of the tank shall be unloaded and disposed of in an environmentally safe manner. The tank and equipment shall then be repassivated as described above.

15.5.3.14 The concentration and stability of the hydrogen peroxide solution shall be determined again. If the same values are obtained within the limits of error as in paragraph 15.5.3.10, the tank is considered to be properly passivated and the cargo ready for shipment.

15.5.3.15 Actions described in paragraphs 15.5.3.2 to 15.5.3.8 shall be carried out under the supervision of the master or shipper. Actions described in paragraphs 15.5.3.9 to 15.5.3.15 shall be carried out under the on-site supervision and responsibility of a representative of the hydrogen peroxide manufacturer or under supervision and responsibility of another person familiar with the safety-relevant properties of hydrogen peroxide.

15.5.3.16 The following procedure shall be applied when tanks having contained hydrogen peroxide solution are to be used for other products (unless otherwise specified, all steps apply to the tanks and to all associated equipment having been in contact with hydrogen peroxide):

.1 Hydrogen peroxide cargo residue shall be drained as completely as possible from tanks and equipment.

.2 Tanks and equipment shall be rinsed with clean water, and subsequently thoroughly washed with clean water.

.3 The interior of the tanks hall be dried and inspected for any residues.

Steps .1 to .3, in 15.5.3.16 shall be carried out under the supervision of the master or the shipper. Step .3) in paragraph 15.5.3.16 shall be carried out by a person familiar with the safety-relevant properties of the chemical to be transported and of hydrogen peroxide.

SPECIAL CAUTIONS :

1) Hydrogen peroxide decomposition may enrich the atmosphere with oxygen and appropriate precautions shall be observed.

2) Hydrogen gas may be evolved in the passivation processes described in paragraphs 15.5.3.9, 15.5.3.10 .2) and 15.5.3.10 .4), leading to the presence of an explosive atmosphere in the tank. Therefore, appropriate measures must be taken to avoid the build-up or the ignition of such an atmosphere.

15.6 Motor fuel anti-knock compounds (containing lead alkyls)

15.6.1 Tanks used for these cargoes are not to be used for the transportation of any other cargo except those commodities to be used in the manufacture of motor fuel anti-knock compounds containing lead alkyls.

15.6.2 If a cargo pump-room is located on deck level according to 15.17, the ventilation arrangements are to be in compliance with 15.16.

15.6.3 Entry into cargo tanks used for the transportation of these cargoes is not permitted unless approved by IRS.

15.6.4 Air analysis is to be made for lead content to determine if the atmosphere is satisfactory prior to allowing personnel to enter the cargo pump-room or void spaces surrounding the cargo tank.

15.7 Phosphorus, yellow or white

15.7.1 Phosphorus is to, at all times, be loaded, carried and discharged under a water pad of 760 [mm] minimum depth. During discharge operations, arrangements are to be made to ensure that water occupies the volume of phosphorus discharged. Any water discharged from a phosphorus tank is to be returned only to a shore installation.

15.7.2 Tanks are to be designed and tested to a minimum equivalent water head of 2.4 [m] above the top of the tank, under designed loading conditions, taking into account the depth, relative density and method of loading and discharge of the phosphorus.

15.7.3 Tanks are to be so designed as to minimize the interfacial area between the liquid phosphorus and its water pad.

15.7.4 A minimum ullage space of 1% is to be maintained above the water pad. The ullage space is to be filled with inert gas or naturally ventilated by two cowled standpipes terminating at different heights but at least 6 [m] above the deck and at least 2 [m] above the pump house top.

15.7.5 All openings are to be at the top of cargo tanks, and fittings and joints attached thereto are to be materials resistant to phosphorus pentoxide.

15.7.6 Phosphorus is to be loaded at a temperature not exceeding 60°C.

15.7.7 Tank heating arrangements are to be external to tanks and have a suitable method of temperature control to ensure that the temperature of the phosphorus does not exceed 60°C. A high-temperature alarm is to be fitted.

15.7.8 A water drench system acceptable to IRS is to be installed in all void spaces surrounding the tanks. The system is to operate automatically in the event of an escape of phosphorus.

15.7.9 Void spaces referred to in 15.7.8 are to be provided with effective means of mechanical ventilation which is to be capable of being sealed off quickly in an emergency.

15.7.10 Loading and discharge of phosphorus is to be governed by a central system on the ship which, in addition to incorporating high-level alarms, is to ensure that no overflow of tanks is possible and that such operations can be stopped quickly in an emergency from either ship or shore.

15.7.11 During cargo transfer, a water hose on deck is to be connected to a water supply and kept flowing throughout the operation so that any spillage of phosphorus may be washed down with water immediately.

15.7.12 Ship-to-shore loading and discharge connections is to be of a type approved by IRS.

15.8 Propylene oxide and mixtures of ethylene oxide/propylene oxide with an ethylene oxide content of not more than 30% by mass

15.8.1 Products transported under the provisions of this Section are to be acetylene free.

15.8.2 Unless cargo tanks are properly cleaned, these products are not to be carried in tanks which have contained as one of the three previous cargoes any products known to catalyse polymerization, such as:

.1 mineral acids (e.g. sulphuric, hydrochloric, nitric);

.2 carboxylic acids and anhydrides (e.g. formic, acetic);

.3 halogenated carboxylic acids (e.g. chloroacetic);

.4 sulphonic acids (e.g. benzene sulphonic);

.5 caustic alkalies (e.g. sodium hydroxide, potassium hydroxide);

.6 ammonia and ammonia solutions;

.7 amines and amine solutions;

.8 oxidizing substances.

15.8.3 Before loading, tanks are to thoroughly and effectively cleaned, to remove all traces of previous cargoes from tanks and associated pipework, except where the immediately prior cargo has been propylene oxide or ethylene oxide/propylene oxide mixtures. Particular care is to be taken in the case of ammonia in tanks made of steel other than stainless steel.

15.8.4 In all cases, the effectiveness of cleaning procedures for tanks and associated pipework is to checked by suitable testing or inspection, to ascertain that no traces of acidic or alkaline materials remain that might create a hazardous situation in the presence of these products.

15.8.5 Tanks are to be entered and inspected prior to each initial loading of these products to ensure freedom from contamination, heavy rust deposits and visible structural defects. When cargo tanks are in continuous service for these products, such inspections are to be performed at intervals of not more than two years.

15.8.6 Tanks for the carriage of these products are to be of steel or stainless steel construction.

15.8.7 Tanks for the carriage of these products may be used for other cargoes after thorough cleaning of tanks and associated pipework systems by washing or purging.

15.8.8 All valves, flanges, fittings and accessory equipment are to be of a type suitable for use with the products and are to be constructed of steel or stainless steel in accordance with recognized standards. The chemical composition of all material used is to be submitted to IRS for approval prior to fabrication. Discs or disc faces, seats and other wearing parts of valves are to be made of stainless steel containing not less than 11% chromium.

15.8.9 Gaskets are to be constructed of materials which do not react with, dissolve in, or lower the autoignition temperature of, these products and which are fire-resistant and possess adequate mechanical behaviour. The surface presented to the cargo is to be polytetrafluoroethylene (PTFE), or materials giving a similar degree of safety by their inertness. Spirally- wound stainless steel, with a filler of PTFE or similar fluorinated polymer, may be accepted.

15.8.10 Insulation and packing, if used, is to be of a material which does not react with, dissolve in, or lower the autoignition temperature of, these products.

15.8.11 The following materials are generally found unsatisfactory for gaskets, packing and similar uses in containment systems for these products and would require testing before being approved by IRS:

.1 Neoprene or natural rubber, if it comes into contact with the products.

.2 Asbestos, or binders used with asbestos.

.3 Materials containing oxides of magnesium, such as mineral wools.

15.8.12 Threaded joints are not permitted in the cargo liquid and vapour lines.

15.8.13 Filling and discharge piping are to extend to within 100 [mm] of the bottom of the tank or any sump pit.

15.8.14.1 The containment system for a tank containing these products is to have a valved vapour-return connection.

15.8.14.2 The products are to be loaded and discharged in such a manner that venting of the tanks to atmosphere does not occur. If vapour return to shore is used during tank loading, the vapour-return system connected to a containment system for the product is to be independent of all other containment systems.

15.8.14.3 During discharge operations, the pressure in the cargo tank must be maintained above 0.007 MPa gauge.

15.8.15 The cargo may be discharged only by deepwell pumps, hydraulically operated submerged pumps, or inert gas displacement. Each cargo pump is to be arranged to ensure that the product does not heat significantly if the discharge line from the pump is shut off or otherwise blocked.

15.8.16 Tanks carrying these products are to be vented independently of tanks carrying other products. Facilities are to be provided for sampling the tank contents without opening the tank to atmosphere.

15.8.17 Cargo hoses used for transfer of these products are to be marked "FOR ALKYLENE OXIDE TRANSFER ONLY".

15.8.18 Cargo tanks, void spaces and other enclosed spaces, adjacent to an integral gravity cargo tank carrying propylene oxide, are to either contain a compatible cargo (those cargoes specified in 15.8.2 are examples of substances considered incompatible) or be inerted by injection of a suitable inert gas. Any hold space in which an independent cargo tank is located is to be inerted. Such inerted spaces and tanks are to be monitored for these products and oxygen. The oxygen content of these spaces is to be maintained below 2 percent. Portable sampling equipment is satisfactory.

15.8.19 In no case is air to be allowed to enter the cargo pump or piping system while these products are contained within the system.

15.8.20 Prior to disconnecting shore-lines, the pressure in liquid and vapour lines are to be relieved through suitable valves installed at the loading header. Liquid and vapour from these lines are not to be discharged to atmosphere.

15.8.21 Propylene oxide may be carried in pressure tanks or in independent or integral gravity tanks. Ethylene oxide/propylene oxide mixtures are to be carried in independent gravity tanks or pressure tanks. Tanks are to be designed for the maximum pressure expected to be encountered during loading, conveying and discharging cargo.

15.8.22.1 Tanks for the carriage of propylene oxide with a design pressure less than 0.6 bar gauge and tanks for the carriage of ethylene oxide/propylene oxide mixtures with a design pressure less than 0.12 [MPa] gauge are to have a cooling system to maintain the cargo below the reference temperature. (See 1.3.3.1).

15.8.22.2 The refrigeration requirement for tanks with a design pressure less than 0.6 bar gauge may be waived by IRS for ships operating in restricted areas or on voyages of restricted duration, and account may be taken in such cases of any insulation of the tanks. The area and times of year for which such carriage would be permitted would be included in the conditions of carriage of the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk.

15.8.23.1 Any cooling system is to maintain the liquid temperature below the boiling temperature at the containment pressure. At least two complete cooling plants automatically regulated by variations within the tanks are to be provided. Each cooling plant is to be complete with the necessary auxiliaries for proper operation. The control system is also to be capable of being manually operated. An alarm is to be provided to indicate malfunctioning of the temperature controls. The capacity of each cooling system is to be sufficient to maintain the temperature of the liquid cargo below the reference temperature (see 1.3.3.1) of the system.

15.8.23.2 An alternative arrangement may consist of three cooling plants, any two of which are to be sufficient to maintain the liquid temperatures below the reference temperature (see 1.3.3.1).

15.8.23.3 Cooling media which are separated from the products by a single wall only is to be non reactive with the products.

15.8.23.4 Cooling systems requiring compre-ssion of the products are not to be used.

15.8.24 Pressure-relief-valve settings are not to be less than 0.02 MPa gauge and for pressure tanks not greater than 0.7 MPa gauge for the carriage of propylene oxide and not greater than 0.53 MPa gauge for the carriage of propylene oxide/ethylene oxide mixtures.

15.8.25.1 The piping system for tanks to be loaded with these products are to be separated (as defined in 3.1.4) from piping systems for all other tanks, including empty tanks. If the piping system for the tanks to be loaded is not independent (as defined in 1.3.15), the required piping separation is to be accomplished by the removal of spool pieces, valves, or other pipe section, and the installation of blank flanges at these locations. The required separation applies to all liquid and vapour piping, liquid and vapour vent lines and any other possible connections, such as common inert gas supply lines.

15.8.25.2 These products may be transported only in accordance with cargo handling plans that have been approved by IRS. Each intended loading arrangement is to be shown on a separate cargo-handling plan. Cargo-handling plans are to show the entire cargo piping system and the locations for installation of blank flanges needed to meet the above piping separation requirements. A copy of each approved cargo-handling plan is to be maintained on board the ship. The International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk is to be endorsed to include reference to the approved cargo- handling plans.

15.8.25.3 Before each initial loading of these products and before every subsequent return to such service, certification verifying that the required piping separation has been achieved is to be obtained from a responsible person acceptable to the Port Administration and carried on board the ship. Each connection between a blank flange and a pipeline flange is to be fitted with a wire and seal by the responsible person to ensure that inadvertent removal of the blank flange is impossible.

15.8.26.1 No cargo tanks are to be more than 98% liquid full at the reference temperature. (see 1.3.3.1).

15.8.26.2 The maximum volume to which a cargo tank is to be loaded is:

$$V_L = 0.98V \frac{\rho R}{\rho L}$$

where,

V_L = maximum volume to which the tank may be loaded

V = volume of the tank

ρR = density of cargo at the reference temperature (see 1.3.3.1)

ρL = density of cargo at the loading temperature and pressure.

15.8.26.3 The maximum allowable tank filling limits for each cargo tank is to be indicated for each loading temperature which may be applied, and for the applicable maximum reference temperature, on a list to be approved by IRS. A copy of the list is to be permanently kept on board by the master.

15.8.27 The cargo is to be carried under a suitable protective padding of nitrogen gas. An automatic nitrogen make-up system is to be installed to prevent the tank pressure falling below 0.07 bar gauge in the event of product temperature fall due to ambient conditions or maloperation of refrigeration systems. Sufficient nitrogen is to be available on board to satisfy the demand of the automatic pressure control. Nitrogen of commercially pure quality (99.9% by volume) is to be used for padding. A battery of nitrogen bottles connected to the cargo tanks through a pressure reduction valve satisfies the intention of the expression "automatic" in this context.

15.8.28 The cargo tank vapour space is to be tested prior to and after loading to ensure that the oxygen content is 2% by volume or less.

15.8.29 A water-spray system of sufficient capacity is to be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling, and the tank domes. The arrangement of piping and nozzles is to be such as to give a uniform distribution rate of 10 [$l/m^2/min$]. Remote manual operation should be arranged such that remote starting of pumps supplying the water spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected. The water-spray system is to be capable of both local and remote manual operation, and the arrangement is to ensure that any spilled cargo is washed away. Additionally, a water hose with pressure to the nozzle, when atmospheric temperature permit, is to be connected ready for immediate use during loading and unloading operations.

15.8.30 A remotely operated, controlled closing-rate, shutoff valve is to be provided at each cargo-hose connection used during cargo transfer.

15.9 Sodium chlorate solution (50% or less by mass)

15.9.1 Tanks and associated equipment which have contained this product may be used for other cargoes after thorough cleaning by washing or purging.

15.9.2 In the event of spillage of this product, all spilled liquid is to be thoroughly washed away without delay. To minimize fire risk, spillage is not to be allowed to dry out.

15.10 Sulphur liquid (molten)

15.10.1 Cargo tank ventilation is to be provided to maintain the concentration of hydrogen sulphide below one half of its lower explosive limit throughout the cargo-tank vapour space for all conditions of carriage, i.e. below 1.85% by volume.

15.10.2 Where mechanical ventilation systems are used for maintaining low gas concentrations in cargo tanks, an alarm system is to be provided to give warning if the system fails.

15.10.3 Ventilation systems are to be so designed and arranged as to preclude depositing of sulphur within the system.

15.10.4 Openings to void spaces adjacent to cargo tanks are to be so designed and fitted as to prevent the entry of water, sulphur or cargo vapour.

15.10.5 Connections are to be provided to permit sampling and analysing of vapour in void spaces.

15.10.6 Cargo temperature controls are to be provided to ensure that the temperature of the sulphur does not exceed 155°C.

15.10.7 Sulphur (molten) has a flashpoint above 60°C; however, electrical equipment are to be certified safe for gases evolved.

15.11 Acids

15.11.1 The ship's shell plating is not to form any boundaries of tanks containing mineral acids.

15.11.2 Proposals for lining steel tanks and related piping systems with corrosion-resistant materials may be considered by IRS. The elasticity of the lining is not to be less than that of the supporting boundary plating.

IR15.11.2 “Lining” (refer clause 15.11.2 above) is an acid-resistant material that is applied to the tank or piping system in a solid state with a defined elasticity property.

15.11.3 Unless constructed wholly of corrosion-resistant materials or fitted with an approved lining, the plating thickness is to take into account the corrosivity of the cargo.

15.11.4 Flanges of the loading and discharge manifold connections are to be provided with shields, which may be portable, to guard against the danger of the cargo being sprayed; and in addition, drip trays are also to be provided to guard against leakage on to the deck.

15.11.5 Because of the danger of evolution of hydrogen when these substances are being carried, the electrical arrangements are to comply with 10.1.4. The certified safe type equipment is to be suitable for use in hydrogen-air mixtures. Other sources of ignition are not to be permitted in such spaces.

15.11.6 Substances subjected to the requirements of this clause are to be segregated from oil fuel tanks, in addition to the segregation requirements in 3.1.1.

15.11.7 Provision is to be made for suitable apparatus to detect leakage of cargo into adjacent spaces.

15.11.8 The cargo pump-room bilge pumping and drainage arrangements are to be of corrosion-resistant materials.

15.12 Toxic products

15.12.1 Exhaust openings of tank vent systems are to be located:

.1 at a height of B/3 or 6 m, whichever is greater, above the weather deck or, in the case of a deck tank, the access gangway;

.2 not less than 6 [m] above the fore-and-aft gangway, if fitted with 6 [m] of the gangway; and

.3 15 [m] from any opening or air intake to any accommodation and service spaces;

.4 the vent height may be reduced to 3 [m] above the deck or fore-and-aft gangway, as applicable, provided high-velocity vent valves of an approved type, directing the vapour-air mixture upwards in an unimpeded jet with and exit velocity of at least 30 [m/s], are fitted.

15.12.2 Tank venting systems are to be provided with a connection for a vapour return line to the shore installation.

IR15.12.2 Tank venting systems are to be provided with a stop valve for vapour return to shore.

15.12.3 Products are:

.1 not be to stowed adjacent to oil fuel tanks;

.2 to have separate piping systems; and

.3 to have tank vent systems separate from tanks containing nontoxic products.

15.12.4 Cargo tank relief valve settings are to be a minimum of 0.02 MPa gauge.

15.13 Cargoes protected by additives

15.13.1 Certain cargoes, with a reference in column "o" in Sec.17, Table 17.1.1, by the nature of their chemical make-up, tend, to under certain conditions of temperature, exposure to air or contact with a catalyst, to undergo polymerization, decomposition, oxidation or other chemical changes. Mitigation of this tendency is carried out by introducing small amounts of chemical inhibitors into the liquid cargo or controlling the cargo-tank environment.

15.13.2 Ships carrying these cargoes are to be so designed as to eliminate from the cargo tanks and cargo-handling system any material of construction or contaminants which could act as a catalyst or destroy the inhibitor.

15.13.3 Care is to be taken to ensure that these cargoes are sufficiently protected to prevent deleterious chemical change at all times during the voyage. Ships carrying such cargoes are to be provided with a certificate of protection from the manufacturer, and kept during the voyage, specifying:

.1 the name and amount of additive present;

.2 whether the additive is oxygen dependent*;

*(*Refer to MSC-MEPC.2/Circ.14 on products requiring oxygen-dependent inhibitors)*

.3 date additive was put in the product and duration of effectiveness;

.4 any temperature limitations qualifying the additives' effective lifetime; and

.5 the action to be taken should the length of the voyage exceed the effective lifetime of the additives.

15.13.4 Ships using the exclusion of air as the method of preventing oxidation of the cargo are to comply with 9.1.3.

15.13.5 When a product containing an oxygen-dependent inhibitor is to be carried:

.1 in a ship for which inerting is required under SOLAS regulation II-2/4.5.5 (Pt.6, Ch.2, 1.5.5), as amended, the application of inert gas not to take place before loading or during the voyage, but is to be applied before commencement of unloading*;

.2 in a ship to which SOLAS regulation II-2/4.5.5 (Pt.6, Ch.2, 1.5.5), as amended, does not apply, the product may be carried without inertion (in tanks of a size not greater than 3000 m^3). If inertion is to be applied on such a ship, then the application of inert gas is not to take place before loading or during the voyage, but is to be applied before commencement of unloading*.

*(*Refer to MSC-MEPC.2/Circ.14 on products requiring oxygen-dependent inhibitors)*

15.13.6 Venting systems are to be of a design that eliminates blockage from polymer build-up. Venting equipment is to be of a type that can be checked periodically for adequacy of operation.

15.13.7 Crystallization or solidification of cargoes normally carried in the molten state can lead to depletion of inhibitor in parts of the tank contents. Subsequent remelting can thus yield pockets of uninhibited liquid, with the accompanying risk of dangerous polymerization. To prevent this, care is to be taken to ensure that at no time are such cargoes allowed to crystallize or solidify, either wholly or partially, in any part of the tank. Any required heating arrangements are to be such as to ensure that in no part of the tank does cargo become overheated to such an extent that any dangerous polymerization can be initiated. If the temperature from steam coils would induce overheating, an indirect low-temperature heating system is to be used.

15.14 Cargoes with a vapour pressure greater than 0.1013 MPa absolute at 37.8°C

15.14.1 For a cargo referenced in column "o" in Sec.17, Table 17.1.1 to this clause, a mechanical refrigeration system is to be provided unless the cargo system is designed to withstand the vapour pressure of the cargo at 45°C. Where the cargo system is designed to withstand the vapour-pressure of the cargo at 45°C, and no refrigeration system is provided, a notation would be made in the conditions of carriage on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk to indicate the required relief valve setting for the tanks.

15.14.2 A mechanical refrigeration system is to maintain the liquid temperature below the boiling temperature at the cargo-tank design pressure.

15.14.3 When ships operate in restricted areas and at restricted times of the year, or on voyages of limited duration, IRS may agree to waive requirements for a refrigeration system. A notation of any such agreement, listing geographic area restrictions and times of the year, or voyage duration limitations, would be included in the conditions of carriage on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk.

15.14.4 Connections are to be provided for returning expelled gases to shore during loading.

IR15.14.4 Tank venting systems are to be provided with a stop valve for vapour return to shore.

15.14.5 Each tank is to be provided with a pressure gauge which indicates the pressure in the vapour space above the cargo.

15.14.6 Where the cargo needs to be cooled, thermometers are to be provided at the top and bottom of each tank.

15.14.7.1 No cargo tanks is to be more than 98% liquid-full at the reference temperature (R).

15.14.7.2 The maximum volume (V_L) of cargo to be loaded in a tank is to be:

$$V_L = 0.98V\frac{\rho R}{\rho L}$$

where,

V = volume of the tank

ρR = density of cargo at the reference temperature (R)

ρL = density of cargo at loading temperature

R = reference temperature is the temperature at which the vapour pressure of the cargo corresponds to the set pressure of the pressure-relief valve.

15.14.7.3 The maximum allowable tank filling limits for each cargo tank is to be indicated for each loading temperature which may be applied, and for the applicable maximum reference temperature, on a list approved by IRS. A copy of the list should be permanently kept on board by the master.

15.15 Cargo contamination

15.15.1 Where column "o" in the Sec.17, Table 17.1.1 refers to this Section, water is not to be allowed to contaminate this cargo. In addition, the following provisions apply:

.1 Air inlets to pressure/vacuum relief valves of tanks containing the cargo are to be situated at least 2 [m] above the weather deck.

.2 Water or steam is not to be used as the heat transfer media in a cargo temperature control system required by Sec.7.

.3 The cargo is not to be carried in cargo tanks adjacent to permanent ballast or water tanks unless the tanks are empty and dry.

.4 The cargo is not to be carried in tanks adjacent to slop tanks or cargo tanks containing ballast or slops or other cargoes containing water which may react in a dangerous manner. Pumps, pipes or vent lines serving such tanks are to be separate from similar equipment serving tanks containing the cargo. Pipelines from slop tanks or ballast lines are not to pass through tanks containing the cargo unless encased in a tunnel.

15.16 Increased ventilation requirements

For certain products, the ventilation system as described in 12.1.3 is to have a minimum capacity of at least 45 changes of air per hour based upon the total volume of space. The ventilation system exhaust ducts are to discharge at least 10 [m] away from openings into accommodation spaces, work areas or other similar spaces, and intakes to ventilation systems, and at least 4 [m] above the tank deck.

15.17 Special cargo pump-room requirements

For certain products, the cargo pump-room is to be located on the deck level or cargo pumps are to be located in the cargo tank. IRS may give special consideration to cargo pump-rooms below deck.

15.18 Overflow control

15.18.1 The provisions of this clause are applicable where specific reference is made in column "o" in Sec.17, Table 17.1.1, and are in addition to the requirements for gauging devices.

15.18.2 In the event of a power failure on any system essential for safe loading, an alarm is to be given to the operators concerned.

15.18.3 Loading operations are to be terminated at once in the event of any system essential for safe loading becoming inoperative.

15.18.4 Level alarms are to be capable of being tested prior to loading.

15.18.5 The high-level alarm system required under 15.18.6 are to be independent of the overflow control system required by 15.18.7 and are to be independent of the equipment required by 13.1.

15.18.6 Cargo tanks are to be fitted with a visual and audible high-level alarm which complies with 15.18.1 to 15.18.5 and which indicates when the liquid level in the cargo tank approaches the normal full condition.

15.18.7 A tank overflow control system required by this Section is to:

.1 come into operation when the normal tank loading procedures fail to stop the tank liquid level exceeding the normal full condition;

.2 give a visual and audible tank-overflow alarm to the ship's operator; and

.3 provide an agreed signal for sequential shutdown of onshore pumps or valves or both and of the ship's valves. The signal, as well as the pump and valve shutdown, may be dependent on operator's intervention. The use of shipboard automatic closing valves would be permitted only when specific approval has been obtained from IRS and the Port State Authority concerned.

15.18.8 The loading rate (LR) of the tank is not to exceed:

$$LR = \frac{3600\,U}{t}\ [m^3/h]$$

where,

U = ullage volume [m^3] at operating signal level;

t = time[s] needed from the initiating signal to fully stopping the cargo flow into the tank, being the sum of times needed for each step in sequential operations such as operator's responses to signals, stopping pumps and closing valves;

and is to also take into account the pipeline system design pressure.

15.19 Alkyl (C7-C9) nitrates, all isomers

15.19.1 The carriage temperature of the cargo should be maintained below 100°C to prevent the occurrence of self- sustaining, exothermic decomposition reaction.

15.19.2 The cargo may not be carried in independent pressure vessels permanently affixed to the vessel's deck unless:

.1 the ranks are sufficiently insulated from fire; and

.2 the vessel has a water deluge system for the tanks such that the cargo temperature is maintained below 100°C and the temperature rise in the tanks does not exceed 1.5°C/hr for a fire of 650°C (1200°F).

15.20 Temperature sensors

Temperature sensors should be used to monitor the cargo pump temperature to detect overheating due to pump failures.

Section 16

Operational Requirements

IR 16.1 General

IR 16.1.1 The requirements of this Section are not the conditions or maintenance of class but are for the guidance of the master and the Owners of the vessel.

16.1 Maximum allowable quantity of cargo per tank

16.1.1 The quantity of a cargo required to be carried in a type 1 ship is not to exceed 1,250 m^3 in any one tank.

16.1.2 The quantity of cargo required to be carried in a type 2 ship is not to exceed 3,000 m^3 in any one tank.

16.1.3 Tanks carrying liquids at ambient temperatures are to be so loaded as to avoid the tank becoming liquid-full during the voyage, having due regard to the highest temperature which the cargo may reach.

16.2 Cargo information

16.2.1 A copy of this Chapter is to be available on board every ship covered by this Chapter.

16.2.2 Any cargo offered for bulk shipment is to be indicated in the shipping documents by the product name, under which it is listed in Section 17 and 18 of this chapter or the latest edition of MEPC.2/Circ. or under which it has been provisionally assessed. Where the cargo is a mixture, an analysis indicating the dangerous components contributing significantly to the total hazard of the product are to be provided, or a complete analysis if this is available. Such an analysis is to be certified by the manufacturer or by an independent expert acceptable to the National Authority.

16.2.3 Information is to be on board, and available to all concerned, giving the necessary data for the safe carriage of the cargo. Such information is to include a cargo stowage plan to be kept in an accessible place, indicating all cargo on board, including each dangerous chemical carried:

.1 full description of the physical and chemical properties, including reactivity necessary for the safe containment of the cargo;

.2 action to be taken in the event of spills or leaks;

.3 countermeasures against accidental personal contact;

.4 fire-fighting procedures and fire-fighting media;

.5 procedures for cargo transfer, tank cleaning, gas-freeing and ballasting;

.6 for those cargoes required to be stabilized or inhibited, the cargo is to be refused if the certificate required by these paragraphs is not supplied.

16.2.4 If sufficient information necessary for the safe transportation of the cargo is not available, the cargo is to be refused.

16.2.5 Cargoes which evolve highly toxic imperceptible vapours is not to be transported unless perceptible additives are introduced into the cargo.

16.2.6 Where column "o" in Sec.17, Table 17.1.1 refers to this paragraph, the cargo's viscosity at 20°C is to be specified on shipping document and if the cargo's viscosity exceeds 50 mPa.s at 20°C, the temperature at which the cargo has a viscosity of 25 mPa.s is to be specified in the shipping document.

16.2.7 Where column "o" in Sec.17, Table 17.1.1 refers to this paragraph, the cargo's melting point is to be indicated in the shipping document.

16.3 Personnel training

16.3.1 All personnel are to be adequately trained in the use of protective equipment and have basic training in the procedures appropriate to their duties, necessary under emergency conditions.

16.3.2 Personnel involved in cargo operations are to be adequately trained in handling procedures.

16.3.3 Officers are to be trained in emergency procedure to deal with conditions of leakage, spillage or fire involving the cargo based on the guidelines developed by the Organisation* and a sufficient number of them are to be instructed and trained in essential first aid for cargoes carried.

(Refer to the Medical First Aid Guide for use in Accidents Involving Dangerous Goods (MFAG), which provides advice on the treatment of casualties in accordance with the symptoms exhibited as well as equipment and antidotes that may be appropriate for treating the casualty and to the relevant provisions of the STCW Code, parts A and B.)*

16.4 Opening of and entry into cargo tanks

16.4.1 During handling and carriage of cargoes producing flammable or toxic vapours, or both, or when ballasting after the discharge of such cargo, or when loading or unloading cargo, cargo tank lids are always to be kept closed. With any hazardous cargo, cargo tank lids, ullage and sighting ports and tank washing access covers are to be open only when necessary.

16.4.2 Personnel are not to enter cargo tanks, void spaces around such tanks, cargo handling spaces or other enclosed spaces unless:

.1 the compartment is free of toxic vapours and not deficient in oxygen; or

.2 personnel wear breathing apparatus and other necessary protective equipment, and the entire operation is under the close supervision of a responsible officer.

16.4.3 Personnel are not to enter such spaces when the only hazard is of a purely flammable nature, except under the close supervision of a responsible officer.

16.5 Stowage of cargo samples

16.5.1 Samples which have to be kept on board are to be stowed in a designated spaces situated in the cargo area or, exceptionally, elsewhere, subject to the approval of IRS.

16.5.2 The stowage space is to be:

.1 cell-divided in order to avoid shifting of the bottles at sea;
.2 made of material fully resistant to the different liquids intended to be stowed; and
.3 equipped with adequate ventilation arrangements.

16.5.3 Samples which react with each other dangerously are not to be stowed close to each other.

16.5.4 Samples are not to be retained on board longer than necessary.

16.6 Cargoes not to be exposed to excessive heat

16.6.1 Where the possibility exists of a dangerous reaction of a cargo such as polymerization, decomposition, thermal instability or evolution of gas, resulting from local overheating of the cargo in either the tank or associated pipelines, such cargo is to be loaded and carried adequately segregated from other products whose temperature is sufficiently high to initiate a reaction of such cargo. (see 7.1.5.4).

16.6.2 Heating coils in tanks carrying this product are to be blanked off or secured by equivalent means.

16.6.3 Heat-sensitive products are not to be carried in deck tanks which are not insulated.

16.6.4 In order to avoid elevated temperatures, this cargo should not be carried in deck tanks.

Section 17

Summary of Minimum Requirements

17.1 General

17.1.1 The summary of the requirements of this chapter are given in Table 17.1.1 and the notes applicable to the Table 17.1.1 are given in Table 17.1.

Mixtures of noxious liquid substances presenting pollution hazards only and which are assessed or provisionally, assessed under regulation 6.3 of Annex II of MARPOL may be carried under the requirements of the code applicable to the appropriate position of the entry in this section for "noxious liquid substances not otherwise specified" (n.o.s.).

Table 17.1 : Notes		
Product name	(column a)	The product names are to be used in the shipping document for any cargo offered for bulk shipments. Any additional name may be included in brackets after the product name. In some cases, the product names are not identical with the names given in previous issues of the Code.
Pollution category	(column c)	The letter X, Y, Z means the Pollution Category assigned to each product under MARPOL Annex II
Hazards	(column d)	S means that the product is included in the Code because of its safety hazards; P means that the product is included in the Code because of its pollution hazards; and S/P means that the product is included in the Code because of both safety and pollution hazards.
Ship type	(column e)	1 = ship type 1 (2.1.2.1) 2 = ship type 2 (2.1.2.2) 3 = ship type (2.1.2.3)
Tank type	(column f)	1 = independent tank (4.1.1) 2 = integral tank (4.1.2) G = gravity tank (4.1.3) P = pressure tank (4.1.4)
Tank vents	(column g)	Open: open venting Cont: controlled venting
Tank environmental control	(column h)	Inert: inerting (9.1.2.1) Pad: liquid or gas padding (9.1.2.2) Dry: drying (9.1.2.3) Vent: natural or force (9.1.2.4) No: no special requirements under this Code
Electrical equipment	(column i', i'', i''')	Temperature classes (i') T1 to T6 - indicates no requirements blank no information Apparatus group (i'') IIA, IIB or IIC: - indicates no requirements blank no information Flash point (i''') Yes : flashpoint exceeding 60°C (10.1.6) No : flashpoint not exceeding 60°C (10.1.6) NF : nonflammable product (10.1.6)
Gauging	(column j)	O : open gauging (13.1.1.1) R : restricted gauging (13.1.1.2) C : closed gauging (13.1.1.3)
Vapour detection	(column k)	F : flammable vapours T : toxic vapours No: indicates no special requirements under this Code
Fire protection	(column l)	A : alcohol-resistant foam or multi-purpose foam B : regular foam; encompasses all foams that are not of an alcohol-resistant type, including fluoro-protein and aqueous-film - forming foam (AFFF) C : water-spray D : drychemical No : no special requirements under this code
Emergency equipment	(column n)	Yes: see 14.3.1 No: no special requirements under this Code
Specific and operational requirements	(column o)	When specific reference is made to chapters 15 and/or 16, these requirements shall be additional to the requirements in any other column

Table 17.1.1 : Summary of minimum requirements
(For details of various columns, see Table 17.1)

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
Acetic acid	Z	S/P	3	2G	Cont.	No	T1	IIA	No	R	F	A	Yes	15.11.2 to 15.11.4, 15.11.6 to 15.11.8, 15.18.6, 16.2.7
Acetic anhydride	Z	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A	Yes	15.11.2 to 15.11.4, 15.11.6 to 15.11.8, 15.18.6
Acetochlor	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Acetone cyanohydrin	Y	S/P	2	2G	Cont.	No	T1	IIA	Yes	C	T	A	Yes	15.13, 15.12, 15.16 to 15.18, 16.6.1 to 16.6.3
Acetonitrile	Z	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A	No	15.12, 15.18.6
Acetonitrile (Low purity grade)	Y	S/P	3	2G	Cont.	No	T1	IIA	No	R	F-T	AC	No	15.12.3, 15.12.4, 15.18.6
Acid oil mixture from soyabean, corn (maize) and sunflower oil refining	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Acrylamide solution (50% or less)	Y	S/P	2	2G	Open	No			NF	C	No	No	No	15.12.3, 15.13, 15.18.6, 16.6.1, 16.2.7
Acrylic acid	Y	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A	No	15.13, 15.18.6, 16.6.1, 16.2.7
Acrylonitrile	Y	S/P	2	2G	Cont.	No	T1	IIB	No	C	F-T	A	Yes	15.12, 15.13, 15.16, 15.18
Acrylonitrile Styrene copolymer dispersion in polyether polyol	Y	P	3	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Adiponitrile	Z	S/P	3	2G	Cont.	No		IIB	Yes	R	T	A	No	16.2.7
Alachlor technical (90% or more)	X	S/P	2	2G	Open	No			Yes	O	No	A, C	No	15.18.6, 16.2.7
Alcohol (C_9-C_{11}) Poly (2-5-9) ethoxylate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Alcohol (C_6-C_{17}) Poly (3-6) ethoxylates	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Alcohol (C_6- C_{17}) (secondary) Poly (7-12) ethoxylates	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Alcohol (C_{12}-C_{16}) Poly (1-6) ethoxylates	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Alcohol (C_{12}-C_{16}) Poly (20+) ethoxylates	Y	P	3	2G	Open	No			Yes	O	No	A	No	16.2.7
Alcohol (C_{12}-C_{16}) Poly (7-9) ethoxylates	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Alcohols (C_{13}+)	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.7
Alcohols (C_8-C_{11}), primary, linear and essentially linear	Y	S/P	2	2G	Cont.	No	-	-	Yes	R	T	AB C	No	15.12.3, 15.12.4, 15.18.6, 16.2.6, 16.2.7
Alcohols (C_{12}+)	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	AB	No	15.19.6, 16.2.6, 16.2.9
Alcohols (C_{12}-C_{13}), primary, linear and essentially linear	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Alcohols (C_{14}-C_{18}), primary, linear and essentially linear	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6
Alkanes (C_6-C_9)	X	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Iso and cyclo-alkanes(C_{10}-C_{11})	Y	P	3	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6

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Iso and cyclo-alkanes (C_{12+})	Y	P	3	2G	Cont.	No	T3	IIA	No	R	F	A	No	
Alkanes(C_{10}-C_{26}), linear and branched, (flashpoint >60°C)	Y	S/P	3	2G	Open	No	-	-	Yes	O	No	ABC	No	15.19.6
n-Alkanes (C_{10+})	Y	P	3	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Alkaryl polyethers (C_9-C_{20})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Alkenyl (C_{11+}) amide	X	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Alkenyl (C_{16}-C_{20}) succinic anhydride	Z	S/P	3	2G	Cont.	No			Yes	C	T	No	Yes	15,12, 15,16, 15.18
Alkenoic acid, polyhydroxy ester borated	Y	S/P	2	2G	Cont	No	-	-	Yes	R	T	ABC	No	15.12.3, 15.12.4, 15.19.6, 16.2.6
Alkyl acrylate-vinylpyridine copolymer in toluene	Y	P	2	2G	Cont.	No	T4	IIB	No	R	F	A	No	15.20.6, 16.2.9
Alkylaryl phosphate mixtures (more than 40% Diphenyl tolyl phosphate, less than 0.02% ortho-isomers)	X	S/P	1	2G	Cont.	No	T1	IIA	Yes	C	T	ABC	No	15.12, 15.16, 15.18
Alkylated (C_4-C_9) hindered phenols	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	BD	No	15.18.6, 16.2.6, 16.2.7
Alkybenzene, alkylindane, alkylidine mixture (each C_{12}-C_{17})	Z	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Alkyl benzene distillation bottoms	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	ABC	No	15.19.6, 16.2.6
Alkylbenzene mixtures (containing at least 50% of toluence)	Y	S/P	3	2G	Cont.	No	T1	IIA	No	C	F-T	ABC	No	15.12, 15.17, 15.19.6
Alkyl (C_3C_4) benzenes	Y	P	2	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6
Alkyl (C_5-C_8) benzenes	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Alkyl (C_{9+}) benzene	Y	P	3	2G	Open	No			Yes	O	No	AB	No	
Alkyl (C_{11}-C_{17}) benzene sulphonic acid	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6, 16.2.6
Alkylbenzene sulphonic acid, sodium salt solution	Y	S/P	2	2G	Open	No	-	-	NF	O	No	No	No	16.2.7, 15.19.6, 16.2.6
Alkyl(C_{12+}) dimethylamine	X	S/P	1	2G	Cont.	No	-	-	Yes	C	T	BCD	Yes	15.12, 15.16, 15.18
Alkyl dithiocarbamate (C_{19}-C_{35})	Y	P	3	2G	Open	No	-	-	Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Alkyldithiothiadiazole (C_6-C_{24})	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6
Alkyl ester copolymer (C_4-C_{20})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Alkyl (C_8-C_{10}) / (C_{12}-C_{14}):(40% or less/60% or more) polyglucoside solution (55% or less)	Y	P	3	2G	Open	No			Yes	O	No	No	No	15.18.6, 16.2.6, 16.2.7
Alkyl (C_8-C_{10}) / (C_{12}-C_{14}):(60% or more/40% or less) polyglucoside solution (55% or less)	Y	P	3	2G	Open	No			Yes	O	No	No	No	16.2.6, 16.2.7
Alkyl (C_7-C_9) nitrates	Y	S/P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 15.19, 16.6.1, 16.6.2, 16.6.3
Alkyl (C_7-C_{11}) phenol poly (4-12) ethoxylate	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Alkyl (C_8-C_{40}) phenol sulphide	Z	P	3	2G	Open	No			Yes	O	No	AB	No	

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Alkyl (C_8-C_9) phenylamine in aromatic solvents	Y	P	2	2G	Cont.	No			No	R	F	A	No	15.18.6
Alkyl (C_9-C_{15}) phenyl propoxylate	Z	P	3	2G	Open	No			Yes	O	No	AB	No	
Alkyl (C_8-C_{10}) / (C_{12}-C_{14}):(50% / 50%) polyglucoside solution (55% or less)	Y	P	3	2G	Open	No			Yes	O	No	No	No	16.2.7, 16.2.6
Alkyl (C_{12}-C_{14}) polyglucoside solution (55% or less)	Y	P	3	2G	Open	No			Yes	O	No	No	No	15.18.6, 16.2.7
Alkyl (C_8-C_{10}) polyglucoside solution (65% or less)	Y	P	3	2G	Open	No			Yes	O	No	No	No	16.2.6
Alkyl(C_{12}-C_{16}) propoxyamine ethoxylate	X	S/P	2	2G	Cont	No	-	-	Yes	C	T	AC	Yes	15.12, 15.18, 15.19, 16.2.6
Alkyl (C_{10}-C_{20}, saturated and unsaturated) phosphite	Y	P	2	2G	Open	No			Yes	O	No	A	No	16.2.7
Alkyl sulphonic acid ester of phenol	Y	P	3	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Alkyl (C_{18+}) toluenes	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	AB C	No	15.19.6, 16.2.9
Alkyl(C_{18}-C_{28})toluenesulfonic acid	Y	S/P	2	2G	Cont	No	-	-	Yes	C	T	AB C	Yes	15.11.2, 15.11.3, 15.11.4, 15.11.6, 15.11.7, 15.11.8, 15.12 15.18 15.19 16.2.6 16.2.9
Alkyl(C_{18}-C_{28}) toluenesulfonic acid,calcium salts, borated	Y	S/P	3	2G	Cont	No	-	-	Yes	C	T	AB C	Yes	15.12, 15.18, 15.19, 16.2.6
Alkyl (C_{18}-C_{28}) toluenesulphonic acid, calcium salts, high overbase	Y	S/P	3	2G	Cont	No	-	-	Yes	C	T	AB C	Yes	15.12, 15.18, 15.19, 16.2.6
Alkyl (C_{18}-C_{28}) toluenesulphonic acid, calcium salts, low overbase	Y	S/P	2	2G	Cont	No	-	-	Yes	C	T	AB C	Yes	15.12, 15.18, 15.19, 16.2.6
Allyl alcohol	Y	S/P	2	2G	Cont.	No	T2	IIB	No	C	F-T	A	Yes	15.12, 15.16, 15.18
Allyl chloride	Y	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	A	Yes	15.12, 15.16, 15.18
Aluminium chloride/Hydrogen chloride solution	Y	S/P	2	2G	Cont	No	-	-	NF	C	T	No	Yes	15.11 15.12 15.18 15.19
Aluminium sulphate solution	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
2-(2-Aminoethoxy) ethanol	Z	S/P	3	2G	Open	No			Yes	O	No	AD	No	15.18.6
Aminoethyldiethanolamine/ Aminoethy lethanolamine solution	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	16.2.7
Aminoethyl ethanolamine	Z	S/P	3	2G	Open	No	T2	IA	Yes	O	No	A	No	
N-Aminoethylpiperazine	Z	S/P	3	2G	Cont.	No			Yes	R	T	A	No	15.18.6, 16.2.7
2-Amino-2-methyl-1-propanol	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Ammonia aqueous (28% or less)	Y	S/P	2	2G	Cont.	No			NF	R	T	AB C	Yes	15.18.6
Ammonium chloride solution (less than 25%)	Z	S/P	3	2G	Open	No	-	-	NF	O	No	No	No	
Ammonium hydrogen phosphate solution	Z	P	3	2G	Open	No			Yes	O	No	A	No	

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Ammonium lignosulphonate solutions	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	16.2.7
Ammonium nitrate solution (93% or less)	Z	S/P	2	1G	Open	No			NF	O	No	No	No	15.2, 15.11.4, 15.11.6, 15.17, 15.18.6, 16.2.7
Ammonium polyphosphate solution	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Ammonium sulphate solution	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Ammonium sulphide solution (45% or less)	Y	S/P	2	2G	Cont.	No			No	C	F-T	A	Yes	15.12, 15.16, 15.18, 16.6.1, 16.6.2, 16.6.3
Ammonium thiosulphate solution (60% or less)	Z	P	3	2G	Open	No			NF	O	No	No	No	16.2.7
Amyl acetate (all isomers)	Y	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
n-Amyl alcohol	Z	P	3	2G	Cont.	No	T2	IIA	No	R	F	AB	No	
Amyl alcohol, primary	Z	P	3	2G	Cont.	No	T2	IIA	No	R	F	AB	No	
sec-Amyl alcohol	Z	P	3	2G	Cont.	No			No	R	F	AB	No	
tert-Amyl alcohol	Z	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	
tert-Amyl methyl ether	X	P	2	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Aniline	Y	S/P	2	2G	Cont.	No	T1	IIA	Yes	C	T	A	No	15.12, 15.16, 15.18
Aryl polyolefins (C_{11}-C_{50})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Aviation alkylates (C_8 paraffins and iso-paraffines B.Pt.95- 120°C)	X	P	2	2G	Cont.	No	T4	IIA	No	R	F	B	No	15.18.6
Barium long chain (C_{11}-C_{50}) alkaryl sulphonate	Y	S/P	2	2G	Open	No			Yes	O	No	AD	No	15.12.3, 15.18, 16.2.6, 16.2.7
Benzene and mixtures having 10% benzene or more (i)	Y	S/P	3	2G	Cont.	No	T1	IIA	No	C	F-T	AB	No	15.12.1, 15.16, 15.18.6, 16.2.7
Benzene sulphonyl chloride	Z	S/P	3	2G	Cont.	No			Yes	R	T	AD	No	15.18.6, 16.2.7
Benzenetricarboxylic acid, triotyl ester	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Benzyl acetate	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Benzyl alcohol	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Benzyl chloride	Y	S/P	2	2G	Cont.	No	T1	IIA	Yes	C	T	AB	Yes	15.12, 15.13, 15.16, 15.18
Bio-fuel blends of Diesel/gas oil and Alkanes (C_{10}-C_{26}), linear and branched with a flashpoint >60°C (>25% but <99% by volume)	X	S/P	2	2G	Cont	No	-	-	Yes	C	T	AB C	No	15.12 15.17 15.19.6
Bio-fuel blends of Diesel/gas oil and Alkanes (C_{10}-C_{26}), linear and branched with a flashpoint ≦60°C (>25% but <99% by volume)	X	S/P	2	2G	Cont	No	T3	IIA	No	C	F-T	AB C	No	15.12 15.17 15.19.6
Bio-fuel blends of Diesel/gas oil and FAME (>25% but <99% by volume)	X	S/P	2	2G	Cont	No	-	-	Yes	C	T	AB C	No	15.12 15.17 15.19.6
Bio-fuel blends of Diesel/gas oil and vegetable oil (>25% but <99% by volume)	X	S/P	2	2G	Cont	No	-	-	Yes	C	T	AB C	No	15.12 15.17 15.19.6

a	c	d	e	f	g	h	i’	i’’	i’’’	j	k	l	n	o
Bio-fuel blends of Gasoline and Ethyl alcohol (>25% but <99% by volume)	X	S/P	2	2G	Cont	No	T3	IIA	No	C	F-T	A	No	15.12 15.17 15.19.6
Brake fluid base mix: Poly (2-8) alkylene (C_2-C_3) glycols/Polyalkylene (C_2-C_{10}) glycols monoalkyl (C_1-C_4) ethers and their borate esters	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	
Bromochloromethane	Z	S/P	3	2G	Cont.	No			NF	R	T	No	No	
Butele oligomer	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Butyl acetate (all isomers)	Y	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Butyl acrylate (all isomers)	Y	S/P	2	2G	Cont.	No	T2	IIB	No	R	F-T	A	No	15.13, 15.18.6, 16.6.1, 16.6.2
tert-Butyl alcohol	Z	P	3	2G	Cont.	No	T1	IIA	No	R	F	A	No	
Butylamine (all isomers)	Y	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A	Yes	15.12, 15.17, 15.19.6
Butylbenzenes (all isomers)	X	P	2	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6
Butyl benzyl phthalate	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Butyl butyrate (all isomers)	Y	P	3	2G	Cont.	No	T1	IIA	No	R	F	A	No	15.19.6
Butyl/Decyl/Cetyl/Eicosyl methacylate mixture	Y	S/P	2	2G	Cont.	No			Yes	R	No	AD	No	15.13, 16.6.1, 16.6.2, 15.18.6
Butylene glycol	Z	P	3	2G	Open	No			Yes	O	No	A	No	
1,2-Butylene oxide	Y	S/P	3	2G	Cont.	Inert	T2	IIB	No	R	F	AC	No	15.8.1 to 15.8.7, 15.8.12, 15.8.13, 15.8.16, 15.8.17, 15.8.18, 15.8.19, 15.8.21, 15.8.25, 15.8.27, 15.8.29, 15.18.6
n-Butyl ether	Y	S/P	3	2G	Cont.	Inert	T4	IIB	No	R	F-T	A	No	15.4.6, 15.12, 15.18.6
Butyl methacrylate	Z	S/P	3	2G	Cont.	No	T1	IIA	No	R	F-T	AD	No	15.13, 15.19.6, 16.6.1, 16.6.2
n-Butyl propionate	Y	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Butyraldehyde (all isomers)	Y	S/P	3	2G	Cont.	No	T3	IIA	No	R	F-T	A	No	15.18.6
Butyric acid	Y	S/P	3	2G	Cont.	No			Yes	R	No	A	No	15.11.2 to 15.11.4, 15.11.6 to 15.11.8, 15.18.6
gamma-Bytyrolactone	Y	P	3	2G	Open	No			Yes	O	No	AB	No	15.18.6
Calcium alkaryl sulphonate (C_{11}-C_{50})	Z	S/P	3	2G	Cont	No			Yes	C	T	ABC	Yes	15.12 15.17 15.19
Calcium alkyl (C_{10}-C_{28}) salicylate	Y	S/P	2	2G	Cont	No			Yes	R	T	ABC	No	15.12.3 15.12.4 15.19.6 16.2.9
Calcium hydroxide slurry	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	16.2.7
Calcium hypochlorite solution (15% or less)	Y	S/P	2	2G	Cont.	No			NF	R	No	No	No	15.18.6
Calcium hypochlorite solution (more than 15%)	X	S/P	1	2G	Cont.	No			NF	R	No	No	No	15.18, 16.2.7
Calcium lignosulphonate solutions	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	16.2.7
Calcium long-chain alkyl (C_5-C_{10}) phenate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Calcium long-chain alkyl (C_{11}-C_{40}) phenate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6

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Calcium long-chain alkyl phenate sulphide (C_8-C_{40})	Y	S/P	2	2G	Open	No			Yes	O	No	ABC	No	15.19.6, 16.2.6
Calcium long-chain alkyl (C_{18}-C_{28}) salicylate	Y	S/P	2	2G	Cont	No			Yes	C	T	ABC	Yes	15.12 15.17 15.19 16.2.6 16.2.9
Calcium long-chain alkyl salicylate (C_{13+})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Calcium nitrate/ Magnesium nitrate/ Potassium chloride solution	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	16.2.7
epsilon-Caprolactam (molten or aqueous solutions)	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Carbolic oil	Y	S/P	2	2G	Cont.	No			Yes	C	F-T	A	No	15.12, 15.18.6, 16.2.7
Carbon disulphide	Y	S/P	2	1G	Cont.	Pad + Inert	T6	IIC	No	C	F-T	C	Yes	15.3, 15.12, 15.18
Carbon tetrachloride	Y	S/P	2	2G	Cont.	No			NF	C	T	No	Yes	15.12, 15.16, 15.18.6
Cashew nut shell oil (untreated)	Y	S	2	2G	Cont.	No			Yes	R	T	AB	No	15.18.6, 16.2.6, 16.2.7
Castor oil	Y	P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Cesium formate solution	Y	S/P	3	2G	Open	No	-	-	NF	O	No	No	No	15.19.6
Cetyl/Eicosyl methacrylate mixture	Y	S/P	2	2G	Open	No			Yes	O	No	AD	No	15.13, 16.6.1, 16.6.2, 15.18.6, 16.2.7
Chlorinated paraffins (C_{10}-C_{13})	X	P	1	2G	Open	No			Yes	O	No	A	No	15.18, 16.2.6
Chlorinated paraffins (C_{14}-C_{17}) (with 50% chlorine or more and less than 1% C_{13} or shorter chains)	X	P	1	2G	Open	No	-	-	Yes	O	No	A	No	15.19
Chloroacetic acid (80% or less)	Y	S/P	2	2G	Cont.	No			NF	C	No	No	No	15.11.2, 15.11.4, 15.11.6, 15.11.7, 15.11.8, 15.12.3, 15.18, 16.2.7
Chlorobenzene	Y	S/P	2	2G	Cont.	No	T1	IIA	No	R	F-T	AB	No	15.18.6
Chloroform	Y	S/P	3	2G	Cont.	No			NF	R	T	No	Yes	15.12, 15.18.6
Chlorohydrins (crude)	Y	S/P	2	2G	Cont.	No	T3	IIA	No	C	F-T	A	No	15.12, 15.19
4-Chloro-2-methylphenoxyacetic acid, dimethylamine salt solution	Y	P	2	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.7
o-Chloronitrobenzene	Y	S/P	2	2G	Cont.	No			Yes	C	T	ABD	No	15.12, 15.16, 15.17, 15.18, 16.2.6, 16.2.7
1-(4-Chlorophenyl)-4-4, dimethyl-pentan-3-one	Y	P	2	2G	Open	No			Yes	O	No	ABD	No	15.18.6, 16.2.6, 16.2.7
2-or3-Chloro-propionic acid	Z	S/P	3	2G	Open	No			Yes	O	No	A	No	15.11.2 to 15.11.4, 15.11.6 to 15.11.8, 16.2.7
Chlorosulphonic acid	Y	S/P	1	2G	Cont.	No			NF	C	T	No	Yes	15.11.2 to 15.11.8, 15.12, 15.15.1, 15.18
m-Chlorotoluene	Y	S/P	2	2G	Cont.	No	T4	IIA	No	R	F-T	AB	No	15.19.6
o-Chlorotoluene	Y	S/P	2	2G	Cont.	No	T1	IIA	No	R	F-T	AB	No	15.19.6

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p-Chlorotoluene	Y	S/P	2	2G	Cont.	No	T1	IIA	No	R	F-T	AB	No	15.19.6, 16.2.9
Chlorotoluenes (mixed isomers)	Y	S/P	2	2G	Cont.	No			No	R	F-T	AB	No	15.18.6
Choline chloride solutions	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Citric acid (70% or less)	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Coal tar	X	S/P	2	2G	Cont.	No	T2	IIA	Yes	R	No	BD	No	15.18.6, 16.2.6, 16.2.7
Coal tar naphtha solvent	Y	S/P	2	2G	Cont.	No	T3	IIA	No	R	F-T	AD	No	15.18.6, 16.2.7
Coal tar pitch (molten)	X	S/P	2	1G	Cont.	No	T2	IIA	Yes	R	No	BD	No	15.18.6, 16.2.6, 16.2.7
Cocoa butter	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.19.6, 16.2.6, 16.2.7
Coconut oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Coconut oil fatty acid	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Coconut oil fatty acid methyl ester	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6
Copper salt of long chain (C_{17+}) alkanoic acid	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Corn Oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Cotton seed Oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Creosote (coal tar)	X	S/P	2	2G	Cont.	No	T2	IIA	Yes	R	T	AD	No	15.12.3, 15.12.4, 15.18.6, 16.2.6, 16.2.7
Cresols (all isomers)	Y	S/P	2	2G	Open	No	T1	IIA	Yes	O	No	AB	No	15.18.6, 16.2.7
Cresylic acid, dephenolized	Y	S/P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6
Cresylic acid, sodium salt solution	Y	S/P	2	2G	Open	No			Yes	O	No	No	No	15.18.6, 16.2.7
Crotonaldehyde	Y	S/P	2	2G	Open	No	T3	IIB	No	R	F-T	A	Yes	15.12, 15.17, 15.18.6
1,5,9-Cyclododecatriene	X	S/P	1	2G	Cont.	No			Yes	R	T	A	No	15.13, 15.18, 16.6.1, 16.6.2
Cycloheptane	X	P	2	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6
Cyclohexane	Y	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6, 16.2.9
Cyclohexanole	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.7
Cyclohexanone	Z	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	A	No	15.18.6
Cyclohexanone, Cyclohexanol mixture	Y	S/P	3	2G	Cont.	No			Yes	R	F-T	A	No	15.18.6
Cyclohexyl acetate	Y	P	3	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6
Cyclohexylamine	Y	S/P	3	2G	Cont.	No	T3	IIA	No	R	F-T	AC	No	15.18.6
1,3-Cyclopentadiene dimer (molten)	Y	P	2	2G	Cont.	No	T1	IIB	No	R	F	A	No	15.19.6, 16.2.6, 16.2.9
Cyclopentane	Y	P	2	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Cyclopentene	Y	P	2	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
p-Cymene	Y	P	2	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Decahydronaphthalene	Y	P	2	2G	Cont.	No	T3	IIA	No	R	F	AB	No	15.19.6
Decanoic acid	X	P	2	2G	Open	No			Yes	O	No	A	No	16.2.7
Decene	X	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6

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Decyl acrylate	X	S/P	1	2G	Open	No	T3	IIA	Yes	O	No	ACD	No	15.13, 15.18, 16.6.1, 16.6.2
Decyl alcohol (all isomers)	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7 (e)
Decyloxytetrahydrothio-phene dioxide	X	S/P	2	2G	Cont.	No			Yes	R	T	A	No	15.18.6, 16.2.7
Diacetone alcohol	Z	P	3	2G	Cont.	No			No	R	F	A	No	
Dialkykl (C_8-C_9) diphenylamines	Z	P	3	2G	Open	No			Yes	O	No	AB	No	
Dialkyl (C_7-C_{13}) phthalates	X	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Dibromomethane	Y	S/P	2	2G	Cont.	No			NF	R	T	No	No	15.12.3, 15.18
Dibutylamine	Y	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	ACD	No	15.18.6
Dibutyl hydrogen phosphonate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
2,6-Di-tert-butylphenol	X	P	1	2G	Open	No	-	-	Yes	O	No	AB CD	No	15.19, 16.2.7
Dibutyl phthalate	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Dichlorobenzenes (all isomers)	X	S/P	2	2G	Cont.	No	T1	IIA	Yes	R	T	ABD	No	15.18.6
Decyl/Dodecyl/Tetradecyl alcohol mixture	Y	S/P	2	2G	Cont	No			Yes	R	T	ABC	No	15.12.3 15.12.4 15.19.6 16.2.9
Dialkyl (C_9-C_{10}) phthalates	Y	S/P	2	2G	Open	No			Yes	O	No	ABC	No	15.19.6 16.2.6
Dialkyl thiophosphates sodium salts solution	Y	S/P	2	2G	Open	No			Yes	R	T	AC	No	15.12.3 15.12.4 15.19.6 16.2.9
Dibutyl terephthalate	Y	P	2	2G	Open	No	-	-	Yes	O	No	ABC	No	15.19.6 16.2.9
3-4 Dichloro-1-butene	Y	S/P	2	2G	Cont.	No	T1	IIA	No	C	F-T	ABC	Yes	15.12.3, 15.17, 15.19.6
1-1-Dichloroethane	Z	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	A	Yes	15.18.6
Dichloroethyl ether	Y	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A	No	15.18.6
1,6-Dichlorohexane	Y	S/P	2	2G	Cont.	No	-	-	Yes	R	T	AB	No	15.19.6
2,2'-Dichloroisopropyl ether	Y	S/P	2	2G	Cont.	No			Yes	R	T	ACD	No	15.12, 15.16, 15.18
Dichloromethane	Y	S/P	3	2G	Cont.	No	T1	IIA	Yes	R	T	No	No	15.18.6
2,4-Dichlorophenol	Y	S/P	2	2G	Cont.	Dry			Yes	R	T	A	No	15.18.6, 16.2.6, 16.2.7
2,4-Dichlorophenoxyacetic acid, diethanolamine salt solution	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.7
2,4-Dichlorophenoxyacetic acid, diethanolamine salt solution (70% or less)	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.7
2,4-Dichlorophenoxyacetic acid, triisopropanolamine salt solution	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.6, 16.2.7
1,1-Dichloropropane	Y	S/P	2	2G	Cont.	No	T4	IIA	No	R	F-T	AB	No	15.12, 15.19.6
1,2-Dichloropropane	Y	S/P	2	2G	Cont.	No	T1	IIA	No	R	F-T	AB	No	15.12, 15.18.6
1,3-Dichloropropene	X	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	AB	Yes	15.12, 15.16, 15.17, 15.18
Dichloropropene / Dichloropropane mixtures	X	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	A, B, D	Yes	15.12, 15.17, 15.18, 15.19

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2,2-Dichloropropionic acid	Y	S/P	3	2G	Cont.	Dry			Yes	R	No	A	No	15.11.2, 15.11.4, 15.11.6, 15.11.7, 15.11.8, 15.19.6, 16.2.7
Dicyclopentadiene, Resin Grade, 81-89%	Y	S/P	2	2G	Cont	Inert	T2	IIB	No	C	F-T	ABC	Yes	15.12 15.13 15.17 15.19
Diethanolamine	Y	S/P	3	2G	Open	No	T1	IIA	Yes	O	No	A	No	16.2.6, 16.2.7
Diethylamine	Y	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	A	Yes	15.12, 15.18.6
Diethylamino-ethanol	Y	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	AC	No	15.18.6
2,6-Diethy laniline	Y	S/P	3	2G	Open	No			Yes	O	No	BCD	No	15.18.6, 16.2.7
Diethylbenzene	Y	P	2	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Diethylene glycol dibutyl ether	Z	S/P	3	2G	Open	No	-	-	Yes	O	No	A	No	
Diethylene glycol dibutyl ether	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	
Diethylene glycol phthalate	Y	P	3	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6
Diethylenetriamine	Y	S/P	3	2G	Open	No	T2	IIA	Yes	O	No	A	No	15.18.6
Diethylenetriaminepentaacetic acid, pentasodium salt solution	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	
Diethyl ether	Z	S/P	2	1G	Cont.	Inert	T4	IIB	No	C	F-T	A	Yes	15.4, 15.14, 15.18
Di-(2-ethylhexyl) adipate	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6
Di-(2-ethylhexyl) phosphoric acid	Y	S/P	2	2G	Open	No			Yes	O	No	AD	No	15.18.6
Diethyl phthalate	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Diethyl sulphate	Y	S/P	2	2G	Cont.	No			Yes	C	T	A	No	15.18.6
Diglycidyl ether of bisphenol A	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Diglycidyl ether of bisphenol F	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6
Diheptylphthalate	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6
Di-n-hexyl adipate	X	P	1	2G	Open	No			Yes	O	No	A	No	15.18
Dihexyl phthalate	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6
Diisobutylamine	Y	S/P	2	2G	Cont.	No	T4	IIB	No	R	F-T	ACD	No	15.12.3, 15.19.6
Diisobutylene	Y	P	2	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Disobutyl ketone	Y	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Disobutyl phthalate	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Diisononyl adipate	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6
Disooctyl phthalate	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Diisopropanolamine	Z	S/P	3	2G	Open	No	T2	IIA	Yes	O	No	A	No	16.2.7
Diisopropylamine	Y	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	A	Yes	15.12, 15.18
Diisopropylbenzene (all isomers)	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Diisopropylnaphthalene	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
N,N-Dimethylacetamide	Z	S/P	3	2G	Cont.	No	-	-	Yes	C	T	AC D	No	15.12, 15.16
N,N-Dimethylacetamide solution (40% or less)	Z	S/P	3	2G	Cont.	No			Yes	R	T	B	No	15.12.1, 15.16
Dimethyl adipate	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Dimethylamine solution (45% or less)	Y	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	AC D	No	15.12, 15.18.6
Dimethylamine solution (greater than 45% but not greater than 55%)	Y	S/P	2	2G	Cont.	No	T2	IIB	No	C	F-T	AC D	Yes	15.12, 15.17, 15.19
Dimethylamine solution (greater than 55% but not greater than 65%)	Y	S/P	2	2G	Cont.	No	T2	IIB	No	C	F-T	AC D	Yes	15.12, 15.14, 15.17, 15.19
N,N-Dimethylcyclohexylamine	Y	S/P	2	2G	Cont.	No	T3	IIB	No	R	F-T	AC	No	15.12, 15.18, 15.19.6
Dimethyl disulphide	Y	S/P	2	2G	Cont.	No	T3	IIA	No	R	F-T	B	No	15.12.3, 15.12.4, 15.19.6
N-N-Dimethyldocylamine	X	S/P	1	2G	Cont.	No			Yes	O	No	B	No	15.18
Dimethylethanolamine	Y	S/P	3	2G	Cont.	No	T3	IIA	No	R	F-T	AD	No	15.18.6
Dimethylformamide	Y	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	AD	No	15.18.6
Dimethyl glutarate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Dimethyl hydrogen phosphite	Y	S/P	3	2G	Cont.	No			Yes	R	T	AD	No	15.12.1, 15.18.6
Dimethyl octanoic acid	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Dimethyl phthalate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Dimethylpolysiloxane	Y	P	3	2G	Open	No			Yes	O	No	AB	No	15.18.6
2,2-Dimethylpropane-1,3-diol (molten or solution)	Z	P	3	2G	Open	No			Yes	O	No	AB	No	16.2.7
Dimethyl succinate	Y	P	3	2G	Open	No			Yes	O	No	A	No	16.2.7
Dinitrololuene (molten)	X	S/P	2	2G	Cont.	No			Yes	C	T	A	No	15.12, 15.16, 15.18, 15.20, 16.2.6, 16.2.7, 16.6.4
Dinonyl phthalate	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6
Dioctyl phthalate	X	P	2	2g	Open	No			Yes	O	No	AB	No	15.18.6
1,4-Dioxane	Y	S/P	2	2G	Cont.	No	T2	IIB	No	C	F-T	A	No	15.12, 15.18, 16.2.7
Dipentene	Y	P	3	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Diphenyl	X	P	2	2G	Open	No			Yes	O	No	B	No	15.18.6, 16.2.6, 16.2.7
Diphenylamine (molten)	Y	P	2	2G	Open	No	-	-	Yes	O	No	BD	No	15.18.6, 16.2.6, 16.2.7
Diphenylamine, reaction product with 2,2,4-Trimethylpentene	Y	S/P	1	2G	Open	No			Yes	O	No	A	No	15.18, 16.2.6
Diphenylamines, alkylated	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Diphenyl/Diphenyl ether mixtures	X	P	2	2G	Open	No			Yes	O	No	B	No	15.18.6, 16.2.7
Diphenyl ether	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
Diphenyl ether/Diphenyl phenyl ether mixture	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Diphenylmethane diisocyanate	Y	S/P	2	2G	Cont.	Dr y	-	-	Yes (a)	C	T (a)	AB C (b) D	No	15.12, 15.15.2, 15.16, 15.18.6, 16.2.6, 16.2.7
Diphenylol propane-epichlorohydrin resins	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Di-n-propylamine	Y	S/P	2	2G	Cont.	No	T3	IIB	No	R	F-T	A	No	15.12.3, 15.19.6
Dipropylene glycol	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Resin oil, distilled	Y	S/P	2	2G	Cont.	No	T1	II A	No	C	F-T	AB C	No	15.12, 15.16, 15.18.6
Dithiocarbamate ester (C_7-C_{35})	X	P	2	2G	Open	No			Yes	O	No	AD	No	15.18.6, 16.2.7
Ditridecyl adipate	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6
Ditridecyl phthalate	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6
Diundecyl phthalate	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Dodecene (all isomers)	Y	P	2	2G	Cont.	No			No	R	F	AB	No	15.18.6
tert-Dodecanethiol	X	S/P	1	2G	Cont.	No	-	-	Yes	C	T	AB D	Yes	15.12, 15.16, 15.18
Dodecene (all isomers)	X	P	2	2G	Open	No	T3	IIA	Yes	O	No	A	No	15.19.6
Dodecyl alcohol	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Dodecylamine/Tetradecyl amine mixture	Y	S/P	2	2G	Cont.	No			Yes	R	T	AD	No	15.18.6, 16.2.7
Dodecylbenzene	Z	P	3	2G	Open	No	-	-	Yes	O	No	AB	No	
Dodecyl diphenyl ether disulphonate solution	X	S/P	2	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.6
Dodecyl hydroxypropyl sulphide	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Dodecyl methacrylate	Z	S/P	3	2G	Open	No			Yes	O	No	A	No	15.13
Dodecyl/Octadecyl methacrylate (mixture)	Y	S/P	3	2G	Open	No			Yes	O	No	A	No	15.13, 15.18.6, 16.2.6, 16.6.1, 16.6.2
Dodecyl/Pentadecyl methacrylate mixture	Y	S/P	2	2G	Open	No			Yes	O	No	AD	No	15.13, 16.6.1, 16.6.2, 15.18.6
Dodecyl phenol	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6
Dodecyl Xylene	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Drilling brines, (containing zinc salts)	X	P	2	2G	Open	No			Yes	O	No	No	No	15.18.6
Drilling brines, including calcium bromide solution, calcium chloride solution and sodium chloride solution	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Epichlorohydrin	Y	S/P	2	2G	Cont.	No	T2	IIB	No	C	F-T	A	Yes	15.12, 15.17, 15.19
Ethanolamine	Y	S/P	3	2G	Open	No	T2	IIA	Yes	O	F-T	A	No	16.2.9
2-Ethoxyethyl acetate	Y	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Ethoxylated tallow amine (> 95%)	X	S/P	2	2G	Cont	Ine rt	-	-	Yes	C	T	AB C	Yes	15.12 15.17 15.19 16.2.6 16.2.9
Ethoxylated long chain (C_{16+}) alkyloxyalkylamine	Y	S/P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.7
Ethyl acetate	Z	P	3	2G	Cont.	No			No	R	F	AB	No	

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
Ethyl acetoacetate	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Ethyl acrylate	Y	S/P	2	2G	Cont.	No	T2	IIB	No	R	F-T	A	Yes	15.13, 15.18.6, 16.6.1, 16.6.2
Ethylamine	Y	S/P	2	1G	Cont.	No	T2	IIA	No	C	F-T	CD	Yes	15.12, 15.14, 15.18.6
Ethylamine solutions (72% or less)	Y	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	AC	Yes	15.12, 15.14, 15.17, 15.19
Ethyl amyl ketone	Y	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Ethylbenzene	Y	P	2	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Ethyl tert-butyl ether	Y	P	3	2G	Cont.	No	T2	IIB	No	R	F	A	No	15.19.6
Ethyl butyrate	Y	P	3	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6
Ethylcyclohexane	Y	P	2	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6
N-Ethylcyclohexylamine	Y	S/P	2	2G	Cont.	No	T3	IIB	No	R	F-T	A	No	15.19.6
S-Ethyl dipropylthiocarbamate	Y	P	2	2G	Open	No			Yes	O	No	A	No	16.2.7
Ethylene chlorohydrin	Y	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	AD	Yes	15.12, 15.16, 15.18
Ethylene cyanohydrin	Y	S/P	3	2G	Open	No		IIB	Yes	O	No	A	No	15.18.6
Ethylenediamine	Y	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A	No	15.18.6, 16.2.7
Ethylenediaminetetraacetic acid, tetrasodium salt solution	Y	S/P	3	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6
Ethylene dibromide	Y	S/P	2	2G	Cont.	No			NF	C	T	No	Yes	15.12, 15.18.6, 16.2.7
Ethylene dichloride	Y	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	AB	No	15.18
Ethylene glycol	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Ethylene glycol acetate	Y	P	3	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6
Ethylene glycol butyl ether acetate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Ethylene glycol diacetate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Ethylene glycol methyl ether acetate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.19.6
Ethylene glycol monoalkyl ethers	Y	S/P	3	2G	Cont.	No	T2	IIB	No	R	F	A	No	15.19.6, 16.2.9
Ethylene glycol phenyl ether	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	16.2.7
Ethylene glycol phenyl ether/Diethylene glycol phenyl ether mixture	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	16.2.7
Ethylene oxide/Propylene oxide mixture with an ethylene oxide content of not more than 30% by mass	Y	S/P	2	1G	Cont.	Inert	T2	IIB	No	C	F-T	AC	No	15.8, 15.12, 15.14, 15.18
Ethylene-Vinyl acetate copolymer (emulsion)	Y	P	3	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6, 16.2.6, 16.2.7
Ethyl 3-ethoxypropionate	Y	P	3	2G	Cont.	No	T2	IIA	No	R	No	A	No	15.19.6
2-Ethylhexanoic acid	Y	P	3	2G	Open	No			Yes	O	No	AB	No	15.18.6
2-Ethylhexyl acrylate	Y	S/P	3	2G	Open	No	T3	IIB	Yes	O	No	A	No	15.13, 15.18.6, 16.6.1, 16.6.2
2-Ethylhexylamine	Y	S/P	2	2G	Cont.	No			No	R	F-T	A	No	15.12, 15.18.6

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
2-Ethyl-2 (hydroxymethyl) propane-1,3-diol, C_8-C_{10} ester	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Ethylidene norbornene	Y	S/P	2	2G	Cont.	No	T3	IIB	No	R	F-T	AD	No	15.12.1, 15.19.6
Ethyl methacrylate	Y	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	AD	No	15.13, 15.18.6, 16.6.1, 16.6.2
N-Ethylmethylallylame	Y	S/P	2	2G	Cont.	No	T2	IIB	No	C	F	AC	Yes	15.12.3, 15.16, 15.18
Ethyl propionate	Y	P	3	2G	Open	No	T1	IIA	No	R	F	A	No	15.19.6
2-Ethyl-3-propylacrolein	Y	S/P	3	2G	Cont.	No	T3	IIA	No	R	F-T	A	No	15.19.6, 16.2.9
Ethyl toluene	Y	P	2	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6
Fatty acid (saturated C_{13+})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.7
Fatty acid methyl esters (m)	Y	S/P	2	2G	Cont.	No	-	-	Yes	R	T	ABC	No	15.12.3, 15.12.4, 15.18.6, 16.2.6, 16.2.7
Fatty acids, 12+	Y	S/P	2	2G	Cont.	No	-	-	Yes	R	T	ABC	No	15.2.3, 15.12.4, 15.18.6, 16.2.6, 16.2.7
Fatty acids, C_8-C_{10}	Y	S/P	2	2G	Cont.	No	-	-	Yes	R	T	ABC	No	15.12.3, 15.12.4, 15.18, 16.2.6, 16.2.7
Fatty acids, essentially linear, C_6-C_{18}, 2-ethylhexyl ester	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6
Fatty acids, C_{16+}	Y	P	2	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6
Ferric chloride solutions	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.11, 15.18.6, 16.2.7
Ferric nitrate/nitric acid solution	Y	S/P	2	2G	Cont.	No			NF	R	T	No	Yes	15.11, 15.18
Fish oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Fluorosilicic acid (20-30%) in water solution	Y	S/P	3	1G	Cont.	No	-	-	-NF	R	T	No	Yes	15.11, 15.18.6
Formaldehyde solutions (45% or less)	Y	S/P	3	2G	Cont.	No	T2	IIB	No	R	F-T	A	Yes	15.18.6, 16.2.7
Formamide	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Formic acid	Y	S/P	3	2G	Cont.	No	T1	IIA	No	R	T (g)	A	Yes	15.11.2 to 15.11.4, 15.11.6 to 15.11.8, 15.18.6, 16.2.7
Formic acid (85% or less acid)	Y	S/P	3	2G	Cont.	No			Yes	R	T (g)	A	Yes	15.11.2 to 15.11.4, 15.11.6 to 15.11.8, 15.12.3, 15.12.4, 15.19.6, 16.2.9
Formic acid (over 85%)	Y	S/P	3	2G	Cont	No	T1	IIA	No	R	F-T(g)	A	Yes	15.11.2 to 15.11.4, 15.11.6 to 15.11.8, 15.12.3, 15.12.4 15.19.6, 16.2.9
Formic acid mixture (containing up to 18% propionic acid and up to 25%sodium formate)	Z	S/P	3	2G	Cont	No			Yes	R	T(g)	AC	No	15.11.2 15.11.3 15.11.4 15.11.6 15.11.7 15.11.8 15.12.3 15.12.4 15.19.6
Furfural	Y	S/P	3	2G	Cont.	No	T2	IIB	No	R	F-T	A	No	15.18.6

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
Furfuryl alcohol	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Glucitol/glycerol blend propoxylated (containing less than 10% amines)	Z	S/P	3	2G	Cont.	No	-	-	Yes	R	T	AB C	No	15.12.3, 15.12.4, 15.18.6
Glutaraldehyde solutions (50% or less)	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.18.6
Glycerol monooleate	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Glycerol propoxylated	Z	S/P	3	2G	Cont.	No	-	-	Yes	R	T	AB C	No	15.12.3, 15.12.4, 15.18.6
Glycerol, propoxylated and ethoxylated	Z	P	3	2G	Open	No	-	-	Yes	O	No	AB C	No	
Glycerol/sucrose blend propoxylated and ethoxylated	Z	P	3	2G	Open	No	-	-	Yes	O	No	AB C	No	
Glyceryl triacetate	Z	P	3	2G	Open	No			Yes	O	No	AB	No	
Glycidyl ester of C_{10} trialkylacetic acid	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Glycine, sodium salt solution	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Glycolic acid solution (70% or less)	Z	S/P	3	2G	Open	No	-	-	NF	O	No	No	No	15.18.6, 16.2.7
Glyoxal solution (40% or less)	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Glyoxylic acid solution (50% or less)	Y	S/P	3	2G	Open	No	-	-	Yes	O	No	AC D	No	15.11.2, 15.11.3 15.11.4, 15.11.6, 15.11.7, 15.11.8, 15.18.6, 16.2.7, 16.6.1, 16.6.2, 16.6.3
Glyphosate solution (not containing surfactant)	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Groundnut oil	Y	P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Heptane (all isomers)	X	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6, 16.2.9
n-Heptanoic acid	Z	P	3	2G	Open	No			Yes	O	No	AB	No	
Heptanol (all isomers) (d)	Y	P	3	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Heptene (all isomers)	Y	P	3	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6
Heptyl acetate	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
1-Hexadecylnaphthalene / 1,4-bis(hexadecyl)naphthalene mixture	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Hexamethylenediamine adipate (50% in water)	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Hexamethylenediamine (molten)	Y	S/P	2	2G	Cont.	No	-	-	Yes	C	T	A, C	Yes	15.12, 15.17, 15.18, 15.19.6, 16.2.9
Hexamethylenediamine solution	Y	S/P	3	2G	Cont.	No			Yes	R	T	A	No	15.18.6
Hexamethylene diisocyanate	Y	S/P	2	1G	Cont.	Dry	T1	IIB	Yes	C	T	AC (b) D	Yes	15.12, 15.16, 15.15.1, 15.17, 15.18
Hexamethylene glycol	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Hexamethy leneimine	Y	S/P	2	2G	Cont.	No	T4	IIB	No	R	F-T	AC	No	15.19.6
Hexane (all isomers)	Y	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6

a	c	d	e	f	g	h	i’	i’’	i’’’	j	k	l	n	o
1,6-Hexanediol, distillation overheads	Y	P	3	2G	Open	No	-	-	Yes	O	No	A	No	15,12,3, 15.12.4, 15.18.6, 16.2.7
Hexanoic acid	Y	P	3	2G	Open	No			Yes	O	No	AB	No	15.18.6
Hexanol	Y	P	3	2G	Open	No			Yes	O	No	AB	No	15.18.6
Hexene (all isomers)	Y	P	3	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Hexyl acetate	Y	P	2	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Hydrochloric acid	Z	S/P	3	1G	Cont.	No			NF	R	T	No	Yes	15.11
Hydrogen peroxide solutions (over 60% but not over 70% by mass)	Y	S/P	2	2G	Cont.	No			NF	C	No	No	No	15.5.1, 15.18.6
Hydrogen peroxide solutions (over 8% but not over 60% by mass)	Y	S/P	3	2G	Cont.	No			NF	C	No	No	No	15.5.2, 15.18, 15.18.6
2-Hydroxyethyl acrylate	Y	S/P	2	2G	Cont.	No			Yes	C	T	A	No	15.12, 15.13, 15.18.6, 16.6.1, 16.6.2
N-(Hydroxyethyl) ethylenediaminetriacetic acid, trisodium salt solution	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
2-Hydroxy-4-(methylthio) butanoic acid	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Illipe oil	Y	P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Isoamyl alcohol	Z	P	3	2G	Cont.	No	T2	IIA	No	R	F	AB	No	
Isobutyl alcohol	Z	P	3	2G	Cont.	No	T2	IIA	No	R	F	AB	No	
Isobutyl formate	Z	P	3	2G	Cont.	No	T4	IIA	No	R	F	AB	No	
Isobutyl methacrylate	Z	P	3	2G	Cont.	No	T2	~~IIA~~	No	R	F	A	No	15.12, 15.13, 15.17, 15.19, 16.6.1, 16.6.2
Isophorone	Y	S/P	3	2G	Cont.	No			Yes	R	No	A	No	15.18.6
Isophoronediamine	Y	S/P	3	2G	Cont.	No			Yes	R	T	A	No	16.2.7
Isophorone diisocyanate	X	S/P	2	2G	Cont.	Dry			Yes	C	T	ABD	No	15.12, 15.15.1, 15.16, 15.18.6
Isoprene	Y	S/P	3	2G	Cont.	No	T3	IIB	No	R	F	B	No	15.13, 15.14, 15.18.6, 16.6.1, 16.6.2
Isopropanolamine	Y	S/P	3	2G	Open	No	T2	IIA	Yes	O	F-T	A	No	16.2.7, 15.18.6, 16.2.6
Ispropyl acetate	Z	P	3	2G	Cont.	No	T1	IIA	No	R	F	AB	No	
Isopropylamine	Y	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	CD	Yes	15.12, 15.14, 15.18
Isopropylamine (70% or less) solution	Y	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	CD	Yes	15.12, 15.19.6, 16.2.9
Isopropylcyclohexane	Y	P	2	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6, 16.2.9
Isopropyl ether	Y	S/P	3	2G	Cont.	Inert	T2	IIA	No	R	F	A	No	15.4.6, 15.13.3, 15.19.6
Jatropha Oil	Y	P	2(k)	3G	Open	No	-	-	Yes	O	No	ABC	No	15.19.6 16.2.6
Lactic acid	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Lactonitrile solution (80% or less)	Y	S/P	2	1G	Cont.	No			Yes	C	T	ACD	Yes	15.1, 15.12, 15.16 15.17, 15.18, 16.6.1, 16.6.2, 16.6.3

a	c	d	e	f	g	h	i’	i’’	i’’’	j	k	l	n	o
Lard	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Latex, ammonia (1% or less), inhibited	Y	S/P	3	2G	Open	No	-	-	-Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Latex: Carboxylated styrene-Butadiene copolymer; Styrene-Butadiene rubber	Z	P	3	2G	Open	No	-	-	-Yes	O	No	A	No	16.2.7
Lauric acid	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Ligninsulphonic acid, magnesium salt solution	Z	P	3	2G	Open	No			Yes	O	No	AC	No	
Ligninsulphonic acid, sodium salt solution	Z	P	3	2G	Open	No	-	-	-Yes	O	No	A	No	16.2.7
Linseed oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Liquid chemical wastes	X	S/P	2	2G	Cont.	No			No	C	F-T	A	Yes	15.12, 15.18.6, 20.5.1
Long-chain alkaryl polyether (C_{11}-C_{20})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Long-chain alkaryl sulphonic acid (C_{16}-C_{60})	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.7
Long-chain alkylphenate/Phenol sulphide mixture	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
L-Lysine solution (60% or less)	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Magnesium chloride solution	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Magnesium long-chain alkaryl sulphonate (C_{11}-C_{50})	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Magnesium long-chain alkyl salicylate (C_{11+})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.19.6, 162.6, 16.2.7
Maleic anhydride	Y	S/P	3	2G	Cont.	No			Yes	R	No	AC (f)	No	16.2.7
Mango kernel oil	Y	P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Mercaptobenzothiazol, sodium salt solution	X	S/P	2	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.7
Mesityl oxide	Z	S/P	3	2G	Cont.	No	T2	IIB	No	R	F-T	A	No	15.18.6
Metam sodium solution	X	S/P	1	2G	Cont.	No	-	-	NF	C	T	No	Yes	15.12, 15.17, 15.19
Methacryclic acid – alkoxypoly (alkylene oxide) methacrylate copolymer, sodium salt aqueous solution (45% or less)	Z	S/P	3	2G	Open	No	-	-	NF	O	No	AC	No	16.2.7
Methacrylic acid	Y	S/P	3	2G	Cont.	No			Yes	R	T	A	No	15.13, 16.6.1, 15.18.6, 16.2.7
Methacrylic resin in ethylene dichloride	Y	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	AB	No	15.18, 16.2.7
Methacrylonitrile	Y	S/P	2	2G	Cont.	No	T1	IIA	No	C	F-T	A	Yes	15.12, 15.14, 15.17, 15.19
3-Methoxy-1-butanol	Z	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	
3-Methoxybutyl acetate	Y	P	3	2G	Open	No			Yes	O	No	AB	No	15.18.6
N-(2-Methoxy-1-methyl ethyl)-2-ethyl-6-methyl chloroacetanilide	X	P	1	2G	Open	No			Yes	O	No	A	No	15.18, 16.2.6

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
Methyl acetate	Z	P	3	2G	Cont.	No	T1	IIA	No	R	F	A	No	
Methyl acetoacetate	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Methyl acrylate	Y	S/P	2	2G	Cont.	No	T1	IIB	No	R	F-T	A	Yes	15.13, 15.18.6, 16.6.1, 16.6.2
Methyl alcohol	Y	P	3	2G	Cont.	No	T1	IIA	No	R	F-T	A	No	15.19.6
Methylamine solutions (42% or less)	Y	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	ACD	Yes	15.12, 15.17, 15.19
Methylamyl acetate	Y	P	2	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Methylamyl alcohol	Z	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Methyl amyl ketone	Z	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
N-Methylaniline	Y	S/P	2	2G	Cont	No	-	-	Yes	R	T	ABC	No	15.12.3 15.12.4 15.19.6
Alpha-methylbenzyl alcohol with acetophenone (15% or less	Y	S/P	2	2G	Cont.	No	-	-	Yes	C	T	ABC	Yes	15.12 15.19 15.19 16.2.6 16.2.9
Methylbutenol	Y	P	3	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6, 16.2.9
Methyl tert-butyl ether	Z	P	3	2G	Cont.	No	T1	IIA	No	R	F	AB	No	
Methyl butyl ketone	Y	P	3	2G	Cont.	No	T2	IIA	No	R	F	AB	No	15.19.6
Methylbutynol	Z	P	3	2G	Cont.	No	T4	IIB	No	R	F	A	No	
Methyl butyrate	Y	P	3	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6
Methylcyclohexane	Y	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Methylcyclopentadiene dimer	Y	P	2	2G	Cont.	No	T4	IIB	No	R	F	B	No	15.19.6
Methylcyclopentadienyl manganese tricarbonyl	X	S/P	1	1G	Cont.	No	-	-	Yes	C	T	ABCD	Yes	15.12, 15.17, 15.18, 16.2.7
Methyl diethanolamine	Y	S/P	3	2G	Open	No			Yes	O	No	A	No	16.2.6
2-Methyl-6-ethylaniline	Y	S/P	3	2G	Open	No			Yes	O	No	AD	No	15.18.6
Methyl ethyl ketone	Z	P	3	2G	Cont.	No	T1	IIA	No	R	F	A	No	
2-Methyl-5-ethyl pyridine	Y	S/P	3	2G	Open	No		IIA	Yes	O	No	AD	No	15.18.6
Methyl formate	Z	S/P	2	2G	Cont.	No	T1	IIA	No	R	F-T	A	Yes	15.12, 15.14, 15.19
2-Methylglutaronitrile with 2-Ethylsuccinonitrile (12% or less)	Z	S	2	2G	Cont	No	-	-	Yes	C	T	ABC	Yes	15.12 15.17 15.19
2-Methyl-2-hydroxy-3-butyne	Z	S/P	3	2G	Cont.	No	T3	IIA	No	R	F-T	ABD	No	15.19.6, 16.2.9
Methyl isobutyl ketone	Z	P	3	2G	Cont.	No	T1	IIA	No	R	F	AB	No	
Methyl methacrylate	Y	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A	No	15.13, 15.18.6, 16.6.1, 16.6.2
3-Methyl-3-methoxybutanol	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Methylnaphthalene (molten)	X	S/P	2	2G	Cont.	No			Yes	R	No	AD	No	15.18.6
2-Methyl pyridine	Z	S/P	2	2G	Cont.	No	T1	IIA	No	C	F	A	No	15.12.3, 15.19.6
3-Methyl pyridine	Z	S/P	2	2G	Cont.	No	T1	IIA	No	C	F	AC	No	15.12.3, 15.19
4-Methylpyridine	Z	S/P	2	2G	Cont.	No	T1	IIA	No	C	F-T	A	No	15.12.3, 15.19, 16.2.9
N-Methyl-2-pyrrolidone	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Methyl salicylate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
alpha- Methylstyrene	Y	S/P	2	2G	Cont.	No	T1	IIB	No	R	F-T	AD (j)	No	15.13, 15.18.6, 16.6.1, 16.6.2

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3-(methylthio) propionaldehyde	Y	S/P	2	2G	Cont.	No	T3	IIA	No	C	F-T	BC	Yes	15.12, 15.16, 15.18
Molybdenum Polysulfide Long Chain Alkyl Dithiocarbamide Complex	Y	S/P	2	2G	Cont.	No	-	-	Yes	C	T	ABC	Yes	15.12, 15.17, 15.18, 16.2.6, 16.2.7
Morpholine	Y	S/P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.18.6
Motor fuel anti-knock compounds (containing lead alkyls)	X	S/P	1	1G	Cont.	No	T4	IIA	No	C	F-T	AC	Yes	15.6, 15.12, 15.17, 15.18
Myrcene	X	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6, 16.2.9
Naphthalene (molten)	X	S/P	2	2G	Cont.	No	T1	IIA	No	R	No	AD	No	15.18.6, 16.2.7
Naphthalenesulphonic acid-Formaldehyde copolymer, sodium salt solution	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	16.2.7
Neodecanoic acid	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Nitrating acid (mixture of sulphuric and nitirc acids)	Y	S/P	2	2G	Cont.	No			NF	C	T	No	Yes	15.11, 15.15.1, 15.16, 15.18
Nitric acid (70% and over)	Y	S/P	2	2G	Cont.	No			NF	C	T	No	Yes	15.11, 15.18
Nitric acid (less than 70%)	Y	S/P	2	2G	Cont.	No			NF	R	T	No	Yes	15.11, 15.18
Nitrilotriacetic acid, trisodium salt solution	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Nitrobenzene	Y	S/P	2	2G	Cont.	No	T1	IIA	Yes	C	T	AD	No	15.12, 15.16, 15.17, 15.18, 16.2.7
Nitroethane	Y	S/P	3	2G	Cont.	No	T2	IIB	No	R	F-T	A (f)	No	15.19.6, 16.6.1, 16.6.2, 16.6.4
Nitroethane (80%)/Nitropro-pane (20%)	Y	S/P	3	2G	Cont.	No	T2	IIB	No	R	F-T	A (f)	No	15.19.6, 16.6.1 to 16.6.3
Nitroethane, 1-Nitropropane (each 15% or more) mixture	Y	S/P	3	2G	Cont.	No	T2	IIB	No	R	F	A	No	15.19.6, 16.2.6, 16.6.1, 16.6.2, 16.6.3
o-Nitrophenol (molten)	Y	S/P	2	2G	Cont.	No			Yes	C	T	AD	No	15.12, 15.18.6, 16.2.6, 16.2.7
1- or 2-Nitropropane	Y	S/P	3	2G	Cont.	No	T2	IIB	No	R	F-T	A	No	15.18.6
Nitropropane (60%)/Nitroethane (40%) mixture	Y	S/P	3	2G	Cont.	No	T4	IIB	No	R	F-T	A (f)	No	15.19.6
o- or p-Nitrotoluenes	Y	S/P	2	2G	Cont.	No		IIB	Yes	C	T	AB	No	15.12, 15.17, 15.18.6
Nonane (all isomers)	X	P	2	2G	Cont.	No	T4	IIA	No	R	F	BC	No	15.19.6
Nonanoic acid (all isomers)	Y	P	3	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.7
Nonene (all isomers)	Y	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Nonyl alcohol (all isomers)	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Nonyl methacrylate monomer	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.7
Nonylphenol	X	P	1	2G	Open	No			Yes	O	No	A	No	15.18, 16.2.6, 16.2.7
Nonylphenol poly(4+)ethoxylate	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6
Noxious liquid, N.F.(1) n.o.s. (trade name..., contains...) S.T.1, Cat.X	X	P	1	2G	Open	No	-	-	Yes	O	No	A	No	15.18, 16.2.6

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Noxious liquid, F, (2) n.o.s. (trade name..., contains...) S.T.1, Cat.X	X	P	1	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.18, 16.2.6
Noxious liquid, N.F.(3) n.o.s. (trade name..., contains...) S.T.2, Cat.X	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18, 16.2.6
Noxious liquid, F, (4) n.o.s. (trade name..., contains...) S.T.2,Cat.X	X	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.18, 16.2.6
Noxious liquid, N.F. (5) n.o.s. (trade name..., contains...) S.T.2, Cat.Y	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18, 16.2.6, 16.2.7 (1)
Noxious liquid, F. (6) n.o.s. (trade name..., contains...) S.T.2, Cat.Y	Y	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.18, 16.2.6, 16.2.7 (1)
Noxious liquid, N.F. (7) n.o.s. (trade name..., contains...) S.T.3, Cat.Y	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18, 16.2.6, 16.2.7(1)
Noxious liquid, F. (8) n.o.s. (trade name..., contains...) S.T.3, Cat.Y	Y	P	3	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.18, 16.2.6, 16.2.7 (1)
Noxious liquid, N.F. (9) n.o.s. (trade name..., contains...) S.T.3, Cat.Z	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Noxious liquid, F, (10) n.o.s. (trade name..., contains...) S.T.3, Cat.Z	Z	P	3	2G	Cont.	No	T3	IIA	No	R	F	A	No	
Octamethylcyclotetrasilo xane	Y	P	2	2G	Cont	No	T2	IIA	No	R	F	AC	No	15.19.6 16.2.7
Octane (all isomers)	X	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Octanoic acid (all isomers)	Y	P	3	2G	Open	No			Yes	O	No	A	No	
Octanol (all isomers)	Y	P	2	2G	Open	No			Yes	O	No	A	No	
Octene (all isomers)	Y	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
n-Octyl acetate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Octyl aldehydes	Y	P	2	2G	Cont.	No	T4	IIB	No	R	F	A	No	15.19.6, 16.2.9
Octyl decyl adipate	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.7
Olefin-Alkyl ester copolymer (molecular weight 2000+)	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Olefin Mixture (C_7-C_9) C8 rich, stabilised	X	S/P	2	2G	Cont	No	T3	IIB	No	R	F	AB C	No	15.13 15.19.6
Olefin mixtures (C_5-C_7)	Y	P	3	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Olefin mixtures (C_5-C_{15})	X	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Olefin (C_{13+}, all isomers)	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.7
Alpha-Olefins (C_6-C_{18}) mixtures	X	P	2	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6, 16.2.9
Oleic acid	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.7
Oleum	Y	S/P	2	2G	Cont.	No			NF	C	T	No	Ye s	15.11.2 to 15.11.8, 15.12.1, 15.16.2, 15.16, 15.18, 16.2.6
Oleylamine	X	S/P	2	2G	Cont.	No			Yes	R	T	A	No	15.19.6, 16.2.7
Olive oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7

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Oxygenated aliphatic hydrocarbon mixtures	Z	S/P	3	2G	Open	No	-	-	Yes	O	No	ABC	No	
Palm acid oil	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Palm fatty acid distillate	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Palm kernel acid oil	Y	S/P	2	2G	Open	No			Yes	O	No	ABC	No	16.2.7, 15.19.6, 16.2.6
Palm kernel oil	Y	S/P	2 (k)	2G	Open	No	T3	IIB	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Palm kernel olein	Y	P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.19.6, 16.2.6, 16.2.7
Palm kernel stearin	Y	P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.19.6, 16.2.6, 16.2.7
Palm mid fraction	Y	P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.19.6, 16.2.6, 16.2.7
Palm oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Non-edible industrial grade palm oil	Y	S/P	2	2G	Cont.	No	-	-	Yes	R	No	ABC	No	15.12.3, 15.12.4, 15.19.6, 16.2.6, 16.2.7
Palm oil fatty acid methyl ester	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6, 16.2.7
Palmolein	Y	P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Palm stearin	Y	P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Paraffin wax	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Palm kernel fatty acid distillate	Y	S/P	2	2G	Cont	No	-	-	Yes	R	T	ABC	No	15.19.6 16.2.6 16.2.9
Paraldehyde	Z	S/P	3	2G	Cont.	No	T3	IIB	No	R	F	A	No	15.18.6, 16.2.7
Paraldehyde-ammonia reaction product	Y	S/P	2	2G	Cont.	No	T4	IIB	No	C	F-T	A	No	15.12.3, 15.19
Pentachloroethane	Y	S/P	2	2G	Cont.	No			NF	R	T	No	No	15.12, 15.16, 15.18.6
1,3-Pentadiene	Y	S/P	3	2G	Cont.	No	T1	IIA	No	R	F-T	AB	No	15.13, 15.19.6, 16.6.1 to 16.6.3
1,3-Pentadiene (greater than 50%),cyclopentene and isomers, mixtures	Y	S/P	2	2G	Cont	Inert	T3	IIB	No	C	F-T	ABC	Yes	15.12 15.13 15.17 15.19
Pentaethylenehexamine	X	S/P	2	2G	Open	No		Yes	Yes	O	No	B	Yes	15.19
Pentane (all isomers)	Y	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.14, 15.19.6
Pentanoic acid	Y	P	3	2G	Open	No			Yes	O	No	AB	No	15.18.6
n-Pentanoic acid (64%)/2-Methyl butyric acid (36%) mixture	Y	S/P	2	2G	Open	No	T2		Yes	C	No	AD	No	15.11.2, 15.11.3, 15.11.4, 15.11.6 to 15.11.8, 16.12.3, 15.18
Pentene (all isomers)	Y	P	3	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.14, 15.19.6
n-Pentyl propionate	Y	P	3	2G	Cont.	No	T4	IIA	No	R	F	A	No	15.19.6
Perchloroethylene	Y	S/P	2	2G	Cont.	No			NF	R	T	No	No	15.12.1, 15.12.2, 15.18.6
Petrolatum	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7

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Phenol	Y	S/P	2	2G	Cont.	No	T1	IIA	Yes	C	T	A	No	15.12, 15.18, 16.2.7
1-Phenyl-1-xylyl ethane	Y	P	3	2G	Open	No			Yes	O	No	AB	No	
Phosphate esters, alkyl (C_{12}-C_{14}) amine	Y	P	2	2G	Cont.	No	T4	IIB	No	R	F	A	No	15.19.6, 16.2.6, 16.2.9
Phosphoric acid	Z	S/P	3	2G	Open	No			NF	O	No	No	No	15.11.1 to 15.11.4, 15.11.6 to 15.11.8, 16.2.7
Phosphorus, yellow or white	X	S/P	1	1G	Cont.	Pad + (Vent or Inert)			No (c)	C	No	C	Yes	15.7, 15.18, 16.2.7
Phthalic anhydride (molten)	Y	S/P	2	2G	Cont.	No	T1	IIA	Yes	R	No	AD	No	16.2.7, 15.18.6, 16.2.6
alpha-Pinene	X	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
beta-Pinene	X	P	2	2G	Cont.	No	T4	IIB	No	R	F	A	No	15.19.6
Pine oil	X	P	2	2G	Open	No			Yes	O	No	A	No	16.2.6 16.2.7
Polyacrylic acid solution (40% or less)	Z	S/P	3	2G	Open	No	-	-	Yes	O	No	AC	No	
Polyalkyl (C_{18}-C_{22}) acrylate in xylene	Y	P	2	2G	Cont.	No	T4	IIB	No	R	F	AB	No	15.19.6, 16.2.6 16.2.9
Polyalkylalkenaminesuccinimide, molybdenum oxy sulphide	Y	P	2	2G	Open	No	-	-	Yes	O	No	ABC	No	15.19.6 16.2.6
Poly(ethylene glycol) methylbutenyl ether(MW>1000)	Z	P	3	2G	Open	No	-	-	Yes	O	No	AC	No	16.2.9
Polyolefin amide alkeneamine polyol	Y	P	2	2G	Open	No	-	-	Yes	O	No	ABC	No	15.19.6 16.2.6 16.2.9
Poly(2-8)alkylene glycol monoalkyl (C_1-C_6) ether	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	
Poly(2-8)alkylene glycol monoalkyl (C_1-C_6) ether acetate	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6
Polyalkyl (C_{10}-C_{20}) methacrylate	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6 16.2.7
Polyalkyl (C_{10}-C_{18}) methacrylate/ethylene-propylene copolymer mixture	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Polybutene	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6, 16.2.6
Polybutenyl succinimide	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6, 16.2.6, 16.2.7
Poly(2+)cyclic aromatics	X	P	1	2G	Cont.	No			Yes	R	No	AD	No	15.18, 16.2.6, 16.2.7
Polyether (molecular weight 1350+)	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6, 16.2.6
Polyethylene glycol	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Polyethylene glycol dimethyl ether	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Polyethylene polyamines	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6
Polyethylene polyamines(more than 50% C_5-C_{20} paraffin oil)	Y	S/P	2	2G	Open	No			Yes	O	No	A	No	16.2.7, 15.19.6
Polyferric sulphate solution	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.18.6

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Poly(imioethylene)-graft-N-poly(ethyleneoxy) solution (90% or less)	Z	S/P	3	2G	Open	No	-	-	NF	O	No	AC	No	16.2.7
Polyisobutenamine in aliphatic (C_{10}-C_{14}) solvent	Y	P	3	2G	Open	No	T3	IIA	Yes	O	No	A	No	15.18.6
Polyisobutenyl anhydride adduct	Z	P	3	2G	Open	No			Yes	O	No	AB	No	
Poly(4+)isobutylene	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.7
Polymethylene polyphenyl isocyanate	Y	S/P	2	2G	Cont.	Dry			Yes (a)	C	T (a)	A	No	15.12, 15.16.2, 15.19.6, 16.2.7
Polyolefin (molecular weight 300+)	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6, 16.2.6, 16.2.7
Polyolefin amide alkeneamine (C_{17+})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Polyolefin amide alkeneamine borate (C_{28}-C_{250})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Polyolefinamine (C_{28}-C_{250})	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Polyolefinamine in alkyl (C_2-C_4) benzenes	Y	P	2	2G	Cont.	No	T4	IIB	No	R	F	A	No	15.19.6, 16.2.6, 16.2.7
Polyolefinamine in aromatic solvent	Y	P	2	2G	Cont.	No	T4	IIB	No	R	F	A	No	15.19.6,16.2.6, 16.2.9
Polyolefin aminoester salts (molecular weight 2000+)	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Polyolefin anhydride	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Polyolefin ester (C_{28}-C_{250})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Polyolefin phenolic amine (C_{28}-C_{250})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Polyolefin phosphorosulphide, barium derivative (C_{28}-C_{250})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Poly(20)oxyethylene sorbitan monooleate	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Polypropylene glycol	Z	S/P	3	2G	Cont.	No			Yes	O	No	AB C	No	15.18.6
Polysiloxane	Y	P	3	2G	Cont.	No	T4	IIB	No	R	F	AB	No	15.19.6, 16.2.9
Potassium chloride solution	Z	S/P	3	2G	Open	No	-	-	NF	O	No	A	No	16.2.7
Potassium hydroxide solution	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.18.6
Potassium oleate	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Potassium thiosulphate (50% or less)	Y	P	3	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.7
n-Propanolamine	Y	S/P	3	2G	Open	No			Yes	O	No	AD	No	16.2.7, 15.18.6
beta-Propiolactone	Y	S/P	2	2G	Cont.	No		IIA	Yes	R	T	A	No	15.18.6
2-Propene-1-aminium, N,N-dimethyl-N-2-propenyl-, chloride, homopolymer solution	Y	S/P	3	2G	Open	No	-	-	NF	O	No	No	No	15.19.6
Propionaldehyde	Y	S/P	3	2G	Cont.	No	T4	IIB	No	R	F-T	A	Yes	15.17, 15.19.6

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
Propionic acid	Y	S/P	3	2G	Cont.	No	T1	IIA	No	R	F	A	Yes	15.11.2 to 15.11.4, 15.11.6 to 15.11.8, 15.18.6
Propionic anhydride	Y	S/P	3	2G	Cont.	No	T2	IIA	Yes	R	T	A	No	15.18.6
Propionitrile	Y	S/P	2	1G	Cont.	No	T1	IIB	No	C	F-T	AD	Yes	15.12, 15.16 to 15.18
n-Propyl acetate	Y	P	3	2G	Cont.	No	T1	IIA	No	R	F	AB	No	15.19.6
n-propyl alcohol	Y	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
n-Propylamine	Z	S/P	2	2G	Cont.	Inert	T2	IIA	No	C	F-T	AD	Yes	15.12, 15.18
Propylbenzene (all isomers)	Y	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Propylene glycol methyl ether acetate	Z	P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	
Propylene glycol monoalkyl either	Z	P	3	2G	Cont.	No	T3	IIA	No	R	F	AB	No	
Propylene glycol phenyl ether	Z	P	3	2G	Open	No			Yes	O	No	AB	No	
Propylene oxide	Y	S/P	2	2G	Cont.	Inert	T2	IIB	No	C	F-T	AC	No	15.8, 15.12.1, 15.14, 15.18
Propylene tetramer	X	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Propylene trimer	Y	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6
Pyridine	Y	S/P	3	2G	Cont.	No	T1	IIA	No	R	F	A	No	15.18.6
Pyrolysis gasoline (contang benzene)	Y	S/P	2	2G	Cont.	No	T3	IIA	No	C	F-T	AB	No	15.12, 15.17, 15.19.6
Rapeseed oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Rape seed oil fatty acid methyl esters	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6
Rice bran oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Rosin	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Safflower oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Shea butter	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Sodium alkyl (C_{14}-C_{17}) sulphonates (60-65% solution)	Y	P	2	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.6, 16.2.7
Sodium aluminosilicate slurry	Z	P	3	2G	Open	No			Yes	O	No	AB	No	
Sodium benzoate	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Sodium borohydride (15% or less)/Sodium hydroxide solution	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.6, 16.2.7
Sodium bromide solution (less than 50%)	Y	S/P	3	2G	Open	No	-	-	NF	R	No	No	No	15.19.6
Sodium carbonate solution	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Sodium chlorate solution (50% or less)	Z	S/P	3	2G	Open	No			NF	O	No	No	No	15.9, 15.18.6, 16.2.7
Sodium dichromate solution (70% or less)	Y	S/P	2	2G	Open	No			NF	C	No	No	No	15.12.3, 15.18

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
Sodium hydrogen sulphide (6% or less)/Sodium carbonate (3% or less) solution	Z	P	3	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.7
Sodium hydrogen sulphite solution (45% or less)	Z	S/P	3	2G	Open	No			NF	O	No	No	No	16.2.7
Sodium hydrosulphide/Ammonium sulphide solution	Y	S/P	2	2G	Cont.	No	T4	IIB	No	C	F-T	A	Yes	15.12, 15.14, 15.17, 15.19, 16.6.1, 16.6.2, 16.6.3
Sodium hydrosulphide solution (45% or less)	Z	S/P	3	2G	Cont.	Vent or pad (gas)			NF	R	T	No	No	15.18.6, 16.2.7
Sodium hydroxide solution	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.6, 16.2.7
Sodium hypochlorite solution (15% or less)	Y	S/P	2	2G	Cont.	No			NF	R	No	No	No	15.18.6
Sodium methylate 21-30% in methanol	Y	S/P	2	2G	Cont	No	T1	IIA	No	C	F-T	AC	Yes	15.12, 15.17, 15.19, 16.2.6(only if >28%), 16.2.9
Sodium nitrite solution	Y	S/P	2	2G	Open	No			NF	O	No	No	No	15.12.3.1, 15.12.3.2, 15.18, 16.2.7
Sodium petroleum sulphonate	Y	S/P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6
Sodium poly(4+) acrylate solutions	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	16.2.7
Sodium silicate solution	Y	P	3	2G	Open	No			NF	O	No	No	No	16.2.7
Sodium sulphide solution (15% or less)	Y	S/P	3	2G	Cont.	No			NF	C	T	No	No	15.18.6, 16.2.7
Sodium sulphite solution (25% or less)	Y	P	3	2G	Open	No			NF	O	No	No	No	15.18.6, 16.2.7
Sodium thiocyanate solution (56% or less)	Y	P	3	2G	Open	No			Yes	O	No	No	No	15.18.6, 16.2.7
Soyabean oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6
Styrene monomer	Y	S/P	3	2G	Cont.	No	T1	IIA	No	R	F	AB	No	15.13, 15.19.6, 16.6.1, 16.6.2
Sulphohydrocarbon (C_3-C_{88})	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.19.6, 16.2.6, 16.2.7
Sulpholane	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Sulphur (molten)	Z	S	3	1G	Open	Vent or pad (gas)	T3		Yes	O	F-T	No	No	15.10, 16.2.7
Sulphuric acid	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.11, 15.15.1, 15.18.6
Sulphuric acid, spent	Y	S/P	3	2G	Open	No			NF	O	No	No	No	15.11, 15.15.1, 15.18.6
Sulphurized fat (C_{14}-C_{20})	Z	P	3	2G	Open	No			Yes	O	No	AB	No	
Sulphurized polyolefinamide alkene (C_{28}-C_{250}) amine	Z	P	3	2G	Open	No	-	-	Yes	O	No	A	No	

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
Sunflower seed oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.19.6, 16.2.6, 16.2.9
Tall oil, crude	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	AB C	Yes	15.19.6, 16.2.6
Tall oil, distilled	Y	P	2	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6
Tall oil fatty acid (resin acids less than 20%)	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6
Tall oil pitch	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	AB C	No	15.19.6, 16.2.6
Tallow	Y	P	2 (k)	2G	Open	No	-	-	Yes	O	No	AB C	No	15.18.6, 16.2.6, 16.2.7
Tallow fatty acid	Y	P	2	2G	Open	No	-	-	Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7
Tetrachloroethane	Y	S/P	2	2G	Cont.	No			NF	R	T	No	No	15.12, 15.16, 15.18.6
Tetraethylene glycol	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Tetraethylene pentamine	Y	S/P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Tetrahydrofuran	Z	S	3	2G	Cont.	No	T3	IIB	No	R	F-T	A	No	15.18.6
Tetrahydronaphthalene	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Tetramethylbenzene (all isomers)	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Titanium dioxide slurry	Z	P	3	2G	Open	No			Yes	O	No	AB	No	
Toluene	Y	P	3	2G	Cont.	No	T1	IIA	No	R	F	A	No	15.19.6
Toluenediamine	Y	S/P	2	2G	Cont.	No			Yes	C	T	AD	Yes	15.12, 15.16, 15.18, 16.2.6, 16.2.7
Toluene diisocyanate	Y	S/P	2	2G	Cont.	Dry	T1	IIA	Yes	C	F-T	AC (b) D	Yes	15.12, 15.15.1, 15.16, 15.18, 16.2.7
o-Toluidine	Y	S/P	2	2G	Cont.	No			Yes	C	T	A	No	15.12, 15.16, 15.18
Tributyl phosphate	Y	P	3	2G	Open	No	T3	IIA	Yes	O	No	A	No	15.12.1, 15.19.6, 16.2.9
1,2,3-Trichlorobenzene (molten)	X	S/P	1	2G	Cont.	No			Yes	C	T	AC D	Yes	15.12, 15.16, 15.18, 16.2.7, 16.2.6
1,2,4-Trichlorobenzene	X	S/P	1	2G	Cont.	No			Yes	R	T	AB	No	15.18, 16.2.7
1,1,1-Trichloroethane	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
1,1,2-Trichloroethane	Y	S/P	3	2G	Cont.	No			NF	R	T	No	No	15.12.1, 15.18.6
Trichloroethylene	Y	S/P	2	2G	Cont.	No	T2	IIA	Yes	R	T	No	No	15.12, 15.16, 15.18.6
1,2,3-Trichloropropane	Y	S/P	2	2G	Cont.	No			Yes	C	T	AB D	No	15.12, 15.16, 15.18
1,1,2-Trichloro-1,2,2-Trifluoroethane	Y	P	2	2G	Open	No			NF	O	No	No	No	15.18.6
Tricresyl phosphate (containing l% or more ortho-isomer)	Y	S/P	1	2G	Cont.	No	T2	IIA	Yes	C	No	AB	No	15.12.3, 15.18, 16.2.6
Tricresyl phosphate (containing less than 1% ortho-isomer)	Y	S/P	2	2G	Open	No			Yes	O	No	A	No	15.19.6, 16.2.6
Tridecane	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6
Tridecanoic acid	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6, 16.2.7

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
Tridecyl acetate	Y	P	3	2G	Open	No			Yes	O	No	A	No	15.18.6
Triethanolamine	Z	S/P	3	2G	Open	No		IIA	Yes	O	No	A	No	16.2.7
Triethylamine	Y	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	AC	Yes	15.12, 15.18.6
Triethybenzene	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Triethylenetetramine	Y	S/P	2	2G	Open	No	T2	IIA	Yes	O	No	A	No	15.18.6
Triethyl phosphate	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Triethyl phosphite	Z	S/P	3	2G	Cont.	No			No	R	F-T	AB	No	15.12.1, 15.18.6, 16.2.7
Triisopropanolamine	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Triisopropylated phenyl phosphates	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6
Trimethylacetic acid	Y	S/P	3	2G	Cont.	No			Yes	R	No	A	No	15.11.2 to 15.11.8, 15.18.6, 16.2.6, 16.2.7
Trimethylamine solution (30% or less)	Z	S/P	2	2G	Cont.	No	T3	IIB	No	C	F-T	AC	Yes	15.12, 15.14, 15.19, 16.2.9
Trimethylbenzenes (all isomers)	X	P	2	2G	Cont.	No	T1	IIA	No	R	F	A	No	15.19.6
Trimethylol propane propoxylated	Z	S/P	3	2G	Open	No	-	-	Yes	O	No	ABC	No	
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	Z	P	3	2G	Open	No			Yes	O	No	AB	No	
2,2,4-Trimethyl-1,3-petanediol-1-isobutyrate	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
1,3,5-Trioxane	Y	S/P	3	2G	Cont.	No	T2	IIB	No	R	F	AD	No	15.19.6, 16.2.9
Tripropylene glycol	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Trixylyl phosphate	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.6
Tung oil	Y	S/P	2 (k)	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Turpentine	X	P	2	2G	Cont.	No	T1	IIA	No	R	F	A	No	15.19.6
Undecanoic acid	Y	P	2	2G	Open	No			Yes	O	No	A	No	16.2.6, 16.2.7
1-Undecene	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Undecyl alcohol	X	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6, 16.2.7
Urea/Ammonium nitrate solution	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Urea/Ammonium nitrate solution (containing less than 1% free-ammonia)	Z	S/P	3	2G	Cont.	No			NF	R	T	A	No	16.2.7
Urea/Ammonium phosphate solution	Y	P	2	2G	Open	No			Yes	O	No	A	No	15.18.6
Urea solution	Z	P	3	2G	Open	No			Yes	O	No	A	No	
Valeraldehyde (all isomers)	Y	S/P	3	2G	Cont.	Inert	T3	IIB	No	R	F-T	A	No	15.4.6, 15.18.6
Vegetable acid oils (m)	Y	S/P	2	2G	Open	No	-	-	-Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Vegetable fatty acid distillates (m)	Y	S/P	2	2G	Open	No	-	-	Yes	O	No	ABC	No	15.18.6, 16.2.6, 16.2.7
Vinyl acetate	Y	S/P	3	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.13, 15.18.6, 16.16.1, 16.6.2
Vinyl ethyl ether	Z	S/P	2	1G	Cont.	Inert	T3	IIB	No	C	F-T	A	Yes	15.4, 15.13, 15.14, 15.18, 16.6.1, 16.6.2

a	c	d	e	f	g	h	i'	i''	i'''	j	k	l	n	o
Vinylidene chloride	Y	S/P	2	2G	Cont.	Inert	T2	IIA	No	R	F-T	B	Yes	15.13, 15.14, 15.18.6, 16.6.1, 16.6.2
Vinyl neodecanoate	Y	S/P	2	2G	Open	No			Yes	O	No	AB	No	15.13, 15.18.6, 16.6.1, 16.6.2
Vinyltoluene	Y	S/P	2	2G	Cont	No	T1	IIA	No	R	F	AB	No	15.13, 15.19.6, 16.6.1, 16.6.2
Waxes	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
White spirit, low (15-20%) aromatic	Y	P	2	2G	Cont.	No	T3	IIA	No	R	F	A	No	15.19.6, 16.2.9
Wood lignin with sodium acetate/oxalate	Z	S/P	3	2G	Open	No	-	-	NF	O	No	No	No	
Xylenes	Y	P	2	2G	Cont.	No	T1	IIA	No	R	F	A	No	15.19.6, 16.2.9 (h)
Xylenes/ethylbenzene (10% or more) mixture	Y	P	2	2G	Cont.	No	T2	IIA	No	R	F	A	No	15.19.6
Xylenol	Y	S/P	2	2G	Open	No		IIA	Yes	O	No	AB	No	15.18.6, 16.2.7
Zinc alkaryl dithiophosphate (C_7-C_{16})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6, 16.2.7
Zinc alkenyl carboxamide	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6
Zinc alkyl dithiophosphate (C_3-C_{14})	Y	P	2	2G	Open	No			Yes	O	No	AB	No	15.18.6, 16.2.6

Notes:

a	If the product to be carried contains flammable solvents such that the flashpoint does not exceed 60°C then special electrical systems and a flammable-vapour detector should be provided.

b	Although water is suitable for extinguishing open-air fires involving chemicals to which this footnote applies, water should not be allowed to contaminate closed tanks containing these chemicals because of the risk of hazardous gas generation.

c	Phosphorus, yellow or white is carried above its auto-ignition temperature and therefore flashpoint is not appropriate. Electrical equipment requirements may be similar to those for substances with a flashpoint above 60°C.

d	Requirements are based on those isomers having a flashpoint of 60°C, or less; some isomers have a flashpoint greater than 60°C, and therefore the requirements based on flammability would not apply to such isomers.

e	Applies to n-decyl alcohol only.

f	Dry chemical is not be used as fire extinguishing media.

g	Confined spaces are to be tested for both formic acid vapours and carbon monoxide gas, a decomposition product.

h	Applies to p-xylene only.

i	For mixtures containing no other components with safety hazards and where the pollution category is Y or less.

j	Only certain alcohol-resistant foams are effective.

k	Requirements for Ship Type identified in column e might be subject to regulation 4.1.3 of Annex II of MARPOL 73/78.

l	Applicable when the melting point is equal to greater than 0°C.

m	From vegetable oils specified in this chapter.

Section 18

List of Chemicals to which this Chapter does not Apply

18.1 The following are chemicals which have been reviewed for their safety and pollution hazards and determined not to present hazards to such an extent as to warrant application of this Chapter.

18.2 Although the chemicals listed in this Section fall outside the scope of the Chapter, it is to be noted that some safety precautions may be needed for their safe transportation. Accordingly, IRS would prescribe appropriate safety requirements.

18.3 Some chemicals are identified as falling into pollution category Z and therefore, subject to certain operational requirements of Annex II of MARPOL 73/78.

18.4 Liquid mixtures which are assessed or provisionally assessed under regulation 6.3 of Annex II of MARPOL as falling into pollution category Z or OS and which do not present safety hazards, may be carried under the appropriate entry in this Section for "Noxious or Non-Noxious Liquid Substances, not otherwise specified (n.o.s.)".

18.5 Explanatory notes to Table 18.1.1 are given below:

Product name	The product name is to be used in the shipping document for any cargo offered for bulk shipments. Any additional name may be included in brackets after the product name. In some cases, the product names are not identical with the names given in previous issues of the Code.
Pollution category	The letter Z means the pollution category assigned to each product under Annex II of MARPOL 73/78. OS means the product was evaluated and found to fall outside the categories X, Y or Z.

Table 18.1.1	
Product Name	**Pollution Category**
Acetone	Z
Alcoholic beverages, n.o.s.	Z
Apple juice	OS
n-Butyl alcohol	Z
sec-Butyl alcohol	Z
Calcium Carbonate Slurry	OS
Calcium nitrate solutions (50% or less)	Z
Clay slurry	OS
Coal slurry	OS
Diethylene glycol	Z
Ethyl alcohol	Z
Ethylene carbonate	Z
Glucose solution	OS
Glycerine	Z
Glycerol ethoxylated	OS
Hexamethylenetetramine solutions	Z
Hexylene glycol	Z
Hydrogenated starch hydrolysate	OS
Isopropyl alcohol	Z
Kaolin slurry	OS
Lecithin	OS
Magnesium hydroxide slurry	Z
Maltitol solution	OS
N-Methylglucamine solution (70% or less)	Z
Methyl propyl ketone	Z
Microsilica Slurry	OS
Molasses	OS
Noxious liquid, (11) n.o.s. (trade name …, contains …) Cat.Z	Z
Non-noxious liquid, (12) n.o.s. (trade name …, contains …) Cat OS	OS
Orange Juice (Concentrated/Non-Concentrated)	OS
Polyaluminium chloride solution	Z
Polyglycerin, sodium salt solution (containing less than 3% sodium hydroxide)	Z
Potassium Chloride Solution (<26%)	OS
Potassium formate solutions	Z
Propylene carbonate	Z
Propylene glycol	Z
Sodium acetate solutions	Z
Sodium Bicarbonate Solution (<10%)	OS
Sodium sulphate solutions	Z
Sorbitol solution	OS
Sulphonated polyacrylate solution	Z
Tetraethyl silicate monomer/oligomer (20% in ethanol)	Z
Triethylene glycol	Z
Vegetable protein solution (hydrolysed)	OS
Water	OS

Section 19

Index of Products Carried in Bulk

19.1 General

IR19.1.1 For complete list of products covered by Sec.17 and 18 of this chapter, reference is to be made to the "Index of Products" given in IBC Code Chapter 19. The index of products contains information regarding the Index Name, Product Name and the UN Number.

Section 20

Transport of Liquid Chemical Wastes

20.1 Preamble

20.1.1 Maritime transport of liquid chemical wastes could present a threat to human health and to the environment.

20.1.2 Liquid chemical wastes are, therefore, to be transported in accordance with relevant international conventions and recommendations and, in particular, where it concerns maritime transport in bulk, with the requirements of this Chapter.

20.2 Definitions

For the purpose of this section:

20.2.1 "Liquid chemical wastes" are substances, solutions or mixtures, offered for shipment, containing or contaminated with one or more constituents which are subject to the requirements of this Chapter and for which no direct use is envisaged but which are carried for dumping, incineration or other methods of disposal other than at sea.

20.2.2 "Transboundary movement" means maritime transport of wastes from an area under the national jurisdiction of one country to or through an area under the national jurisdiction of another country, or to or through an area not under the national jurisdiction of any country, provided at least two countries are concerned by the movement.

20.3 Applicability

20.3.1 The requirements of this Section are applicable to the transboundary movement of liquid chemical wastes in bulk by seagoing ships and are to be considered in conjunction with all other requirements of this Chapter.

20.3.2 The requirements of this Section do not apply to:

.1 wastes derived from shipboard operations which are covered by the requirements of MARPOL 73/78;

.2 substances, solutions or mixtures containing or contaminated with radioactive materials which are subject to the applicable requirements for radioactive materials.

20.4 Permitted shipments

20.4.1Transboundary movement of wastes is permitted to commence only when:

.1 notification has been sent by the competent authority of the country of origin, or by the generator or exporter through the channel of the competent authority of the country of origin, to the country of final destination; and

.2 the competent authority of the country of origin, having received the written consent of the country of final destination stating that the wastes will be safely incinerated or treated by other methods of disposal, has given authorization to the movement.

20.5 Documentation

20.5.1 In addition to the documentation specified in 16.2 of this Chapter, ships engaged in transboundary movement of liquid chemical wastes are to carry on board a waste movement document issued by the competent authority of the country of origin.

20.6 Classification of liquid chemical wastes

20.6.1 For the purpose of the protection of the marine environment, all liquid chemical wastes transported in bulk are to be treated as Category A noxious liquid substances, irrespective of the actual evaluated category.

20.7 Carriage and handling of liquid chemical wastes

20.7.1 Liquid chemical wastes are to be carried in ships and cargo tanks in accordance with the minimum requirements for liquid chemical wastes specified in Sec.17, unless there are clear grounds indicating that the hazards of the wastes would warrant:

.1 carriage in accordance with the ship type 1 requirements; or

.2 any additional requirements of this Chapter applicable to the substance or, in case of a mixture, its constituent presenting the predominant hazard.

Section 21

Inert Gas Systems

IR21.1 Application

IR21.1.1 Chemical tankers of deadweight in excess of 20,000 tons having individual cargo tank capacity exceeding 3000 m^3 or cargo tanks fitted with washing machine with a nozzle capacity exceeding 17.5 m^3/hr or a total through put per tank of 110 m^3/hr and intended for carriage of chemicals with flash point less than 60°C are to be fitted with an inert gas system complying with requirements given in part 5, Ch.2, Sec 11. (Also refer Pt.6, Ch.2, 1.5.5.2).

IR21.1.2 As an alternative to water seal in the inert gas line on deck, as required by Pt.5, Ch.2, Sec.11.6.5, an arrangement consisting of automatically operated double shut off valves in series with a venting valve in between may be accepted (double block and bleed type), subject to the following conditions:

The operation of the valve is to be automatically executed. Signal(s) for opening / closing is (are) to be taken from the process directly, e.g. inert gas flow or differential pressure.

Alarm for faulty operation of the valves is to be provided, e.g. the operation status of "Blower stop" and "supply valve(s) open" is an alarm condition.

21.2 Operation of inert gas systems

21.2.1 The inert gas systems for all tankers are to be operated in accordance with requirements laid down in Pt. 6, Ch.5, 3.3.3. In applying Pt. 6, Ch.5, 3.3.3, the requirements of Pt.6, Ch. 8, 15.2.2.1.4 are also to be complied with.

End of Chapter

Chapter 4

Liquefied Gas Carriers

Contents

Introduction

IR1.0 General

IR1.1 These Rules have been prepared to ensure that ships for the carriage of liquefied gases in bulk built with a view to classification with IRS, will also comply with the requirements of IMO International Code for the construction and Equipment of ships carrying liquefied gases in bulk as interpreted by IRS.

IR1.2 Responsibility for interpretation of the IGC Code requirements for the purpose of issuing an International Certificate of Fitness for the carriage of Liquefied Gases in Bulk lies with the statutory authority of the country where the ship is to be registered.

IR1.3 These Rules are considered to incorporate the final text of the IGC code in full. The number of various clauses in these Rules are the same as those appearing in the IMO code. The numbering of paragraphs which are not there in the IMO code, but have been included in these Rules for the purpose of classification have been prefixed by the letters 'IR'.

IR1.4 The IGC code contains requirements for operational matters which are not within the scope of classification requirements and IRS does not require these to be investigated for the purpose of classification. However, these matters are the responsibility of the National Authority or Administration responsible for issuing the International Certificate of Fitness.

IR1.5 For the purpose for classification the following words in the construction rules of the IMO code (not in the survey regulations) have been changed as appropriate:

'Organization'	to	'IRS'
'should be'	to	'is to be' or 'are to be'
'chapter'	to	'section'
'code'	to	'chapter'
'Section'	to	'Clause'

IR1.6 Where for the purpose of issuing an International Certificate of Fitness, a National Authority has specifically accepted an equivalent under the terms of the IGC code or has adopted an interpretation different from that agreed to by IRS, individual consideration will be given to the acceptance of the equivalent or interpretation concerned for the purpose of classification.

IR2.0 Classification and class notations

IR2.1 The regulations for classification and the assignment of class notations are given in Pt.1 of the Rules, to which reference is to be made. In general, the class notation to be assigned would be "**SUL Liquefied gas carrier**" where the vessel is designed and constructed primarily for the carriage of liquefied gases in bulk in integral, membrane or independent tanks.

IR2.2 Additional class notation in respect of following items will be assigned as appropriate:

- Ship Type, i.e. 1G, 2G, 2PG or 3G;
- Type of Tanks;
- Name(s) of gas(es);
- Maximum vapour pressure (at sea and in harbor); minimum and (where necessary) maximum cargo temperature;
- Design ambient temperatures (when the ship is suitable for continuous service in high and/or low temperature climatic conditions).

Preamble(To the IGC Code)

1. The purpose of this Code is to provide an international standard for the safe carriage by sea in bulk, of liquefied gases and certain other substances listed that are listed in chapter 19 (Section 19 of this Chapter). Through consideration of the products carried, it prescribes the design and construction standards of the ships involved and the equipment they should carry to minimize the risk to the ship, its crew and the environment.

2. The basic philosophy is one of ship types related to the hazards of the products covered by the Code. Each of the products may have one or more hazard properties which include flammability, toxicity, corrosivity and reactivity. A further possible hazard may arise where products are transported under cryogenic or pressure conditions.

3. Severe collisions or strandings could lead to cargo tank damage and result in uncontrolled release of the product. Such a release could result in evaporation and dispersion of the product and, in some cases, could cause brittle fracture of the ship's hull. The requirements in the Code are intended to minimize this risk as far as practicable, based upon present knowledge and technology.

4. Throughout the development of the Code, it was recognized that it must be based on sound naval architectural and engineering principles and the best understanding available as to the hazards of the various products covered. Gas carrier design technology is not only a complex technology but is rapidly evolving and the Code shall not remain static. The Organization will periodically review the Code, continually taking into account both experience and future development.

5. Requirements for new products and their conditions of carriage will be circulated as recommendations, on an interim basis, when adopted by the Maritime Safety Committee of the Organization, prior to the entry into force of the appropriate amendments, under the terms of article VIII of the International Convention for the Safety of Life at Sea, 1974.

6. The Code primarily deals with ship design and equipment. To ensure the safe transport of the products the total system must, however, be appraised. Other important facets of the safe transport of the products, such as training, operation, traffic control and handling in port, are being or will be examined further by the Organization.

7. The development of the Code has been greatly assisted by a number of organizations in consultative status, such as Society of International Gas Tanker and Terminal Operators Limited (SIGTTO) and other organizations, such as members of the International Association of Classification Societies (IACS)

8. Chapter.18 (Section 18 of this chapter) of the Code dealing with operation of liquefied gas carriers highlights the regulations in other chapters (Sections of this chapter) that are operational in nature and mentions those other important safety features that are peculiar to gas carrier operation.

9. The layout of the Code is in line with the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) adopted by the Maritime Safety Committee at its forty-eighth session.Gas carriers may also carry in bulk liquid chemicals covered by IBC Code(Chapter 3), as Prescribed in the IGC Code(this chapter).

10. Floating production, storage and offloading (FPSO) facilities, which are designed to handle liquefied gases in bulk, do not fall under the IGC Code. However, designers of such units may consider using IGC Code to the extent that the Code provides the most appropriate risk mitigation measures for the operations the unit is to perform. Where other more appropriate risk mitigation measures are determined that are contrary to this Code, they shall take precedence over the Code.

Section 1

General

1.0 Goal

To provide an international standard for the safe carriage, by sea in bulk, of liquefied gases by laying down the design and construction standards of ships involved in such carriage and the equipment, they shall carry to minimize the risk to the ship, its crew and to the environment, having regard to the nature of the products including flammability, toxicity, asphyxiation, corrosivity, reactivity and low temperature and vapour pressure.

1.1 Application and implementation

1.1.1 This Chapter applies to ships regardless of their size, including those of less than 500 gross tonnage, engaged in carriage of liquefied gases having a vapour pressure exceeding 2.8 [bar] absolute at a temperature of 37.8°C, and other products as shown in Sec.19, when carried in bulk.

IR 1.1.1 The requirements of this Chapter are in addition to the requirements of Pt.1 to 4 of the Rules.

1.1.2.1 Unless expressly provided otherwise, the Chapter applies to ships whose keels are laid or which are at a similar stage of construction where:

.1 construction identifiable with the ship begins; and

.2 assembly of that ship has commenced, comprising at least 50 tonnes or 1 per cent of the estimated mass of all structural material, whichever is less;

on or after 01 July, 2016.

1.1.2.2 For the purpose of this chapter, the expression “ship constructed” means ships the keels of which are at a similar stage of construction.

1.1.2.3 Unless expressly provided otherwise, for ships constructed on or after 1 July 1986 and before 1 July 2016, the requirements which are applicable under IGC Code, as adopted by resolution MSC.5(48) as amended by resolutions MSC.17(58), MSC.30(61), MSC.32(63), MSC.59(67), MSC.103(73), MSC.177(79) and MSC.220(82), are to be complied with.

1.1.3 A ship, irrespective of the date of construction, which is converted to a gas carrier on or after 1 July, 2016, is to be treated as a gas carrier constructed on the date on which such conversion commences.

IR 1.1.3 For classification, these Rules apply to ships where the midship section is approved on or after the effective date.

1.1.4.1 When cargo tanks contain products for which the Chapter requires a type 1G ship, neither flammable liquids having a flashpoint of 60°C (closed cup test) or less nor flammable products listed in Sec.19 are to be carried in tanks located within the protective zones described in 2.4.1.1.

1.1.4.2 Similarly, when cargo tanks contain products for which the Chapter requires a type 2G/2PG ship, the flammable liquids as described in 1.1.4.1 are not to be carried in tanks located within the protective zones described in 2.4.1.2.

1.1.4.3 In each case, for the cargo tanks loaded with products for which this chapter requires a Type 1G or 2G/2PG ship, the restriction applies to the protective zones within the longitudinal extent of the hold spaces for those tanks..

1.1.4.4 The flammable liquids and products described in 1.1.4.1 may be carried within these protective zones when the quantity of products retained in the cargo tanks, for which the Chapter requires a Type 1G or 2G/2PG ship is solely used for cooling, circulation or fuelling purposes.

1.1.5 Except as provided in 1.1.7.1, when it is intended to carry products covered by this chapter and products covered by the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code (Chapter 3)) adopted by resolution MSC.4(48), as may be amended by the Organization , the ship is to comply with the requirements of both Codes appropriate to the products carried.

1.1.6.1 Where it is proposed to carry products that may be considered to come within the scope of the chapter that are not at present designated in Sec.19, the Administration and the port Administrations involved in such carriage should establish Tripartite Agreement based on a provisional assessment and lay down preliminary suitable conditions of carriage based on the principles of the Code.

1.1.6.2 For the evaluation of such products, the manufacturer of the product should submit to the Administration a completed assessment form (see Appendix 1, of IGC Code), which includes the proposed ship type and carriage requirements.

1.1.6.3 When a provisional assessment for a pure or technically pure product has been completed and agreed with the other parties, the Administration will submit the assessment form and a proposal for a new and complete entry in the IGC Code, to the relevant sub-committee of the IMO.

1.1.6.4 After provisional assessment by tripartite agreement and express or tacit agreement has been established, an addendum to the relevant ship's certificate may be issued.

1.1.7.1 The requirements of this chapter are to take precedence when a ship is designed and constructed for the carriage of the following products:

.1 those listed exclusively in Sec.19 of this Chapter; and

.2 one or more of the products that are listed both in this chapter and in the the International Bulk Chemical Code (Chapter 3). These products are marked with an asterisk (*) in column "a" in the Table 19.1.1.

1.1.7.2 When a ship is intended to exclusively carry one or more of the products referred to in 1.1.7.1.2, the requirements of the International Bulk Chemical Code (Chapter 3) as amended will apply.

1.1.8 The ship's compliance with the requirements of the International Gas Carrier Code is to be shown by its International Certificate of Fitness for the carriage of liquefied gases in bulk as described in 1.5. Compliance with the amendments to the Code, as appropriate, is also to be indicated in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

1.1.9 Where reference is made in this chapter to a paragraph, all the provisions of the subparagraph of that designation shall apply.

1.1.10 When a ship is intended to operate for periods at a fixed location in a re-gasification and gas discharge mode or a gas receiving, processing, liquefaction and storage mode, the Administration/ IRS and port Administrations involved in the operation will take appropriate steps to ensure implementation of the provisions of the IGC Code as are applicable to the proposed arrangements. Furthermore, additional requirements will be established based on the principles of the IGC Code as well as recognized standards that address specific risks not envisaged by it. Such risks may include, but not be limited to:

.1 fire and explosion;

.2 evacuation;

.3 extension of hazardous areas;

.4 pressurized gas discharge to shore;

.5 high-pressure gas venting;

.6 process upset conditions;

.7 storage and handling of flammable refrigerants;

.8 continuous presence of liquid and vapour cargo outside the cargo containment system;

.9 tank over-pressure and under-pressure;

.10 ship-to-ship transfer of liquid cargo; and

.11 collision risk during berthing manoeuvres.

1.1.11 Where a risk assessment or study of similar intent is utilized within this chapter, the results are also to include, but not be limited to, the following as evidence of effectiveness:

.1 description of methodology and standards applied;

.2 potential variation in scenario interpretation or sources of error in the study;

.3 validation of the risk assessment process by an independent and suitable third party;

.4 quality system under which the risk assessment was developed;

.5 the source, suitability and validity of data used within the assessment;

.6 the knowledge base of persons involved within the assessment;

.7 system of distribution of results to relevant parties; and

.8 validation of results by an independent and suitable third party.

1.1.12 Although the IGC Code is legally treated as a mandatory instrument under SOLAS Convention, the provisions of Sec 4.28 (4.28 of this chapter) and appendices 1, 3, and 4 of the IGC Code are recommendatory or informative

1.2 Definitions

IR 1.2.1 Following definitions are in addition to the various definitions given in Pt.4 of the Rules.

1.2.1 "**Accommodation spaces**" are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobby rooms, barber shops, pantries without cooking appliances and similar spaces.

1.2.2 "**"A" Class divisions**" are divisions as defined in regulation II-2/3.2 of SOLAS Convention (Rules Pt.6, Ch.1, Cl.3.2).

1.2.3 "**Administration**" means the Government of the State whose flag the ship is entitled to fly. For Administration (Port), see port Administration

1.2.4 **Anniversary date** means the day and the month of each year that will correspond to the date of expiry of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

1.2.5 "**Boiling point**" is the temperature at which a product exhibits a vapour pressure equal to the atmospheric barometric pressure.

1.2.6 "**Breadth (B)**" means the maximum breadth of the ship, measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material. The breadth (B) is to measured in metres.

IR 1.2.6 For the determination of scantlings for hull construction, the breadth (B) to be taken is defined in Pt.3 of the Rules.

1.2.7 "**Cargo area**" is that part of the ship which contains the cargo containment system and cargo pump and compressor rooms and includes deck areas over the full length and breadth of the part of the ship over these spaces. Where fitted, the cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the foremost hold space are excluded from the cargo area.

1.2.8 "**Cargo containment system**" is the arrangement for containment of cargo including, where fitted, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure, if necessary, for the support of these elements. If the secondary barrier is part of the hull structure, it may be a boundary of the hold space.

1.2.9 "**Cargo control room**" is a space used in the control of cargo handling operations.

1.2.10 "**Cargo machinery spaces"** are the spaces where cargo compressors or pumps, cargo processing units, are located, including those supplying gas fuel to the engine-room.

1.2.11 "**Cargo Pumps"** are pumps used for the transfer of liquid cargo including main pumps, booster pumps, spray pumps, etc.

1.2.12 "**Cargoes**" are products listed in Sec.19 that are carried in bulk by ships subject to this chapter.

1.2.13 "**Cargo service spaces**" are spaces within the cargo area, used for workshops, lockers and store-rooms that are of more than 2 [m^2] in area.

1.2.14 "**Cargo tank**" is the liquid-tight shell designed to be the primary container of the cargo and includes all such containment systems whether or not they are associated with the insulation and/or the secondary barriers.

1.2.15 "**Closed loop sampling"** is a cargo sampling system that minimizes the escape of cargo vapour to the atmosphere by returning product to the cargo tank during sampling.

1.2.16 "**Cofferdam**" is the isolating space between two adjacent steel bulkheads or decks. This space may be a void space or ballast space.

1.2.17 "**Control stations**" are those spaces in which ships' radio, main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralized. This does not include special fire control equipment which can be most practically located in the cargo area.

1.2.18 "**Flammable products**" are those identified by an "F" in column "f" in Sec.19 (Table 19.1.1).

1.2.19 "**Flammability limits**" are the conditions defining the state of fuel-oxidant mixture at which application of an adequately strong external ignition source is only just capable of producing flammability in a given test apparatus.

1.2.20 FSS Code is the Fire Safety Systems Code meaning the International Code for Fire Safety Systems, adopted by the Maritime Safety Committee of the IMO by resolution MSC.98(73), as amended.

1.2.21 "**Gas carrier**" is a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas or other products listed in the table of Sec.19.

1.2.22 "**Gas combustion unit (GCU)**" is a means of disposing excess cargo vapour by thermal oxidation.

1.2.23 "**Gas consumer"** is any unit within the ship using cargo vapour as a fuel.

1.2.24 "**Hazardous area"** is an area in which an explosive gas atmosphere is, or may be expected to be present, in quantities that require special precautions for the construction, installation and use of electrical equipment. When a gas atmosphere is present, the following hazards may also be present: toxicity, asphyxiation, corrosivity, reactivity and low temperature. These hazards shall also be taken into account and additional precautions for the ventilation of spaces and protection of the crew will need to be considered. Examples of hazardous areas include, but are not limited to, the following:

.1 the interiors of cargo containment systems and any pipework of pressure-relief or other venting systems for cargo tanks, pipes and equipment containing the cargo;

.2 interbarrier spaces;

.3 hold spaces where the cargo containment system requires a secondary barrier;

.4 hold spaces where the cargo containment system does not require a secondary barrier;

.5 a space separated from a hold space by a single gastight steel boundary where the cargo containment system requires a secondary barrier;

.6 cargo machinery spaces;

.7 areas on open deck, or semi-enclosed spaces on open deck, within 3 [m] of possible sources of gas release, such as cargo valve, cargo pipe flange, cargo machinery space ventilation outlet, etc.;

.8 areas on open deck, or semi-enclosed spaces on open deck within 1.5 [m] of cargo machinery space entrances, cargo machinery space ventilation inlets;

.9 areas on open deck over the cargo area and 3 [m] forward and aft of the cargo area on the open deck up to a height of 2.4 [m] above the weather deck;

.10 an area within 2.4 [m] of the outer surface of a cargo containment system where such surface is exposed to the weather;

.11 enclosed or semi-enclosed spaces in which pipes containing cargoes are located, except those where pipes containing cargo products for boil-off gas fuel burning systems are located;

.12 an enclosed or semi-enclosed space having a direct opening into any hazardous area;

.13 void spaces, cofferdams, trunks, passageways and enclosed or semi-enclosed spaces, adjacent to, or immediately above or below, the cargo containment system;

.14 areas on open deck or semi-enclosed spaces on open deck above and in the vicinity of any vent riser outlet, within a vertical cylinder of unlimited height and 6 [m] radius centred upon the centre of the outlet and within a hemisphere of 6 [m] radius below the outlet; and

.15 areas on open deck within spillage containment surrounding cargo manifold valves and 3 [m] beyond these up to a height of 2.4 [m] above deck.

1.2.25 "**Non-hazardous area"** is an area other than a hazardous area.

1.2.26 "**Hold space**" is the space enclosed by the ship's structure in which a cargo containment system is situated.

1.2.27 "**IBC Code"** means the *International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk*, adopted by the Maritime Safety Committee of the IMO by resolution MSC.4(48), as amended.

1.2.28 "**Independent**" means that a piping or venting system, for example, is in no way connected to another system and there are no provisions available for the potential connection to other systems.

1.2.29 "**Insulation space**" is the space, which may or may not be an interbarrier space, occupied wholly or in part by insulation.

1.2.30 "**Interbarrier space**" is the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material.

1.2.31 "**Length (L)**" is the length as defined in the International Convention on Load Lines in force.
IR 1.2.31 For the determination of scantlings for hull construction, the length (L) to be taken is defined in Pt.3 of the Rules.

1.2.32 "**Machinery spaces of category A**" are those spaces and trunks to those spaces, which contain either:

.1 internal combustion machinery used for main propulsion; or

.2 internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 [kW]; or

.3 any oil-fired boiler or oil fuel unit or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

1.2.33 "**Machinery spaces**" are machinery spaces of category A and other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air-conditioning machinery, and similar spaces; and the trunks to such spaces.

1.2.34 "**MARVS**" is the maximum allowable relief valve setting of a cargo tank (gauge pressure).

1.2.35 **"Nominated surveyor"** is a surveyor nominated/appointed by an Administration to enforce the provisions of the SOLAS Convention regulations with regard to inspections and surveys and the granting of exemptions therefrom.

1.2.36 "**Oil fuel unit**" is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 1.8 bar gauge.

1.2.37 "**Organization**" is the International Maritime Organization (IMO).

1.2.38 "**Permeability of a space**" means the ratio of the volume within that space which is assumed to be occupied by water to the total volume of that space.

1.2.39 **"Port Administration"** means the appropriate authority of the country for the port where the ship is loading or unloading.

1.2.40 "**Primary barrier**" is the inner element designed to contain the cargo when the cargo containment system includes two boundaries.

1.2.41 "**Products"** is the collective term used to cover the list of gases indicated in sec 19 of this chapter.

1.2.42 "**Public spaces"** are those portions of the accommodation that are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

1.2.43 **"Recognized organization"** is an organization authorized by an Administration in accordance with SOLAS regulation XI-1/1.

1.2.44 "**Recognized standards**" are applicable international or national standards acceptable to the Administration or standards laid down and maintained by the recognized organization

1.2.45 "**Relative density**" is the ratio of the mass of a volume of a product to the mass of an equal volume of fresh water.

1.2.46 **"Secondary barrier"** is the liquid-resisting outer element of a cargo containment system, designed to afford temporary containment of any envisaged leakage of liquid cargo through the primary barrier and to prevent the lowering of the temperature of the ship's structure to an unsafe level. Types of secondary barrier are more fully defined in sec 4.

1.2.47 "**Separate systems**" are those cargo piping and vent system that are not permanently connected to each other.

1.2.48 "**Service spaces**" are those used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store-rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

1.2.49 "**SOLAS Convention**" means the International Convention for the Safety of Life at Sea, 1974, as amended.

1.2.50 "**Tank cover**" is the protective structure intended to either protect the cargo containment system against damage where it protrudes through the weather deck or to ensure the continuity and integrity of the deck structure.

1.2.51 "**Tank dome**" is the upward extension of a portion of a cargo tank. In the case of below-deck cargo containment systems, the tank dome protrudes through the weather deck or through a tank cover.

1.2.52 **"Thermal oxidation method"** means a system where the boil-off vapours are utilized as fuel for shipboard use or as a waste heat system subject to the provisions of sec 16 or a system not using the gas as fuel complying with this Code.

1.2.53 "**Toxic products**" are identified by a "T" in column "f" in Sec.19 (Table 19.1.1).

1.2.54 **"Turret compartments"** are those spaces and trunks that contain equipment and machinery for retrieval and release of the disconnectable turret mooring system, high-pressure hydraulic operating systems, fire protection arrangements and cargo transfer valves.

1.2.55 "**Vapour pressure**" is the equilibrium pressure of the saturated vapour above the liquid, expressed in bars absolute at a specified temperature.

1.2.56 "**Void space**" is the enclosed space in the cargo area external to a cargo containment system, other than a hold space, ballast space, fuel oil tank, cargo pumps or compressor room, or any space in normal use by personnel.

1.3 Equivalents

1.3.1 Where this chapter requires that a particular fitting, material, appliance, apparatus, item of equipment or type thereof is to be fitted or carried in a ship, or that any particular provision is to be made, or any procedure or arrangement is to be complied with, the Administration may allow any other fitting, material, appliance, apparatus, item of equipment or type thereof to be fitted or carried, or any other provision, procedure or arrangement to be made in that ship, if it is satisfied by trial thereof or otherwise that such fitting, material, appliances, apparatus, item of equipment or type thereof or that any particular provision, procedure or arrangement is at least as effective as that required by this Chapter. However, the Administration may not allow operational methods or procedures to be made as an alternative to a particular fitting, material, appliance, apparatus, item of equipment, or type thereof that is prescribed by the Chapter, unless such a substitution is specifically allowed by the chapter.

IR 1.3.1 Alternative arrangements or fittings which are considered to be equivalent to those specified in these Rules will be accepted. Arrangements or systems incorporating features not provided for in these Rules will be specially considered.

1.3.2 When the Administration so allows any fitting, material, appliance, apparatus, item of equipment, or type thereof, or provision, procedure or arrangement or novel design or application to be substituted, it should communicate to the Organization(IMO) the particulars thereof together with a report on the evidence submitted, so that the Organization(IMO) may circulate the same to other Contracting Governments to the SOLAS Convention for the information of their officers.

1.4 Surveys and certification

1.4.1 Survey procedure

1.4.1.1 The survey of ships, so far as regards the enforcement of the provisions of this chapter and granting of exemptions therefrom, should be carried out by officers of the Administration. The Administration may, however, entrust the surveys either to surveyors nominated for the purpose or to organizations recognized by it.

1.4.1.2 The recognized organization, referred to in 1.2.43 is to comply with the provisions of the SOLAS Convention and with the Code of recognized organizations (RO Code)

1.4.1.3 The Administration nominating surveyors or recognizing organizations to conduct surveys should, as a minimum, empower any nominated surveyor or recognized organization to:

.1 require repairs to a ship; and

.2 carry out surveys if requested by the appropriate authorities of a port State.

The Administration should notify the Organization(IMO) of the specific responsibilities and conditions of the authority delegated to nominated surveyors or recognized organizations for circulation to the Contracting Governments.

1.4.1.4 When a nominated surveyor or recognized organization determines that the condition of a ship or its equipment does not correspond substantially with the particulars of the International certificate of fitness for the carriage of liquefied gases in bulk or is such that the ship is not fit to proceed to sea without danger to the ship, or persons on board, or without presenting unreasonable threat of harm to the marine environment. the surveyor or organization should immediately ensure that corrective action is taken and should in due course notify the Administration. If such corrective action is not taken the certificate should be withdrawn and the Administration should be notified immediately. If the ship is in a port of another Contracting Government, the appropriate authorities of the port State should be notified immediately. When an officer of the Administration, a nominated surveyor or a recognized organization has notified the appropriate authorities of the port State, the Government of the port State concerned should give the officer , surveyor or organization any necessary assistance to carry out their obligations under this paragraph. When applicable, the Government of the port State concerned should take such steps as will ensure that the ship does not sail until it can proceed to sea or leave the port for the purpose of proceeding to the nearest appropriate repair yard available without danger to the ship or persons on board or without presenting an unreasonable threat of harm to the marine environment.

1.4.1.5 In every case, the Administration should guarantee the completeness and efficiency of the survey, and should undertake to ensure the necessary arrangements to satisfy this obligation.

1.4.2 Survey requirements

IR 1.4.2.1 The Classification Regulations for new construction surveys, the classification of ships not built under survey and Periodical Survey regulations are given in Pt.1 of the Rules.

1.4.2.1 The structure, equipment, fittings, arrangements and material (other than items in respect of which a Cargo Ship Safety Construction Certificate, Cargo Ship Safety Equipment Certificate and Cargo Ship Safety Radio Certificate or Cargo Ship Safety Certificate, required by the SOLAS Convention, are issued) of a gas carrier should be subjected to the following surveys:

.1 An initial survey before the ship is put in service or before the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk is issued for the first time, which should include a complete examination of its structure, equipment, fittings, arrangements and material in so far as the ship is covered by the chapter. This survey should be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of the Chapter.

.2 A renewal survey at intervals specified by the Administration, but not exceeding 5 years, except where 1.4.6.2.1, 1.4.6.5, 1.4.6.6, or 1.4.6.7 is applicable. The renewal survey should be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of the Chapter.

.3 An intermediate survey within 3 months before or after the second anniversary date or within 3 months before or after the third anniversary date of the certificate, which should take the place of one of the annual surveys mentioned in 1.4.2.4. Intermediate surveys should be such as to ensure that the safety equipment, and other equipment and associated pump and piping systems fully comply with the applicable provisions of the Chapter and are in good working order. Such intermediate surveys should be endorsed on the Certificate issued under 1.4.4 or 1.4.5.

.4 An annual survey within 3 months before or after each anniversary date of the Certificate including a general inspection of the structure, equipment, fittings, arrangements and material referred to in 1.4.2.1 to ensure that they remain satisfactory for the service for which the ship is intended. Such annual surveys should be endorsed on the Certificate issued under 1.4.4 or 1.4.5.

.5 An additional survey, either general or partial according to the circumstances, should be made when required after an investigation prescribed in 1.4.3.3, or whenever any important repairs or renewals are made. Such a survey should ensure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are satisfactory; and that the ship is fit to proceed to sea without danger to the ship or persons on board or without presenting unreasonable threat of harm to the marine environment.

1.4.3 Maintenance of conditions after survey

1.4.3.1 The condition of the ship and its equipment should be maintained to conform with the provisions of the Chapter to ensure that the ship will remain fit to proceed to sea without danger to the ship or persons on board or without presenting unreasonable threat or harm to the marine environment.

1.4.3.2 After any survey of the ship, as described in 1.4.2 has been completed, no change should be made in the structure, equipment, fittings, arrangements and material covered by the survey, without the sanction of IRS, except by direct replacement.

1.4.3.3 Whenever an accident occurs to a ship or a defect is discovered, either of which affects the safety of the ship or the efficiency or completeness of its life-saving appliances or other equipment covered by the chapter, the master or owner of the ship should report at the earliest opportunity to the Administration/ IRS, who should cause investigations to be initiated to determine whether a survey, as required by 1.4.2.5, is necessary. If the ship is in a port of another Contracting Government, the master or owner should also report immediately to the appropriate authorities of the port State and the nominated surveyor or recognized organization should ascertain that such a report has been made.

1.4.4 Issue and endorsement of an International Certificate of Fitness of Liquefied Gases in Bulk

1.4.4.1 An International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk should be issued after an initial or renewal survey to a gas carrier engaged on international voyages that comply with the relevant provisions of the Code.

1.4.4.2 Such a certificate should be drawn up in the form corresponding to the model given in the Appendix 2 of IGC Code. If the language used is not English, French or Spanish, the text should include a translation into one of these languages.

1.4.4.3 The certificate issued under the provisions of this clause should be available on board for examination at all times.

1.4.4.4 Notwithstanding any other provisions of the amendments to the Code, adopted by the Maritime Safety Committee by resolution MSC.17(58), any International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk that is current when these amendments enter into force shall remain valid until it expires under the terms of IGC Code prior to the amendments entering into force.

1.4.5 Issue or endorsement of an International Certificate of Fitness of Liquefied Gases in Bulk by another Government

1.4.5.1 A contracting Government to the SOLAS Convention may, at the request of another Contracting Government, cause a ship entitled to fly the flag of the other state to be surveyed and if satisfied that the requirements of the Code are complied with, issue or authorize the issue of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk to the ship and, where appropriate, endorse or authorize the endorsement of the certificate on board the ship in accordance with the Code. Any certificate so issued should contain a statement to the effect that it has been issued at the request of the Government of the State whose flag the ship is entitled to fly.

1.4.6 Duration and validity of an International Certificate of Fitness of Liquefied Gases in Bulk

1.4.6.1 An International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk is to be issued for a period specified by the Administration which is not to exceed 5 years.

1.4.6.2.1 Notwithstanding the provisions of 1.4.6.1, when the renewal survey is completed within 3 months before the expiry date of the existing certificate, the new certificate is to be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of expiry of the existing Certificate.

1.4.6.2.2 When the renewal survey is completed after the expiry date of the existing certificate, the new certificate is to be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of expiry of the existing certificate.

1.4.6.2.3 When the renewal survey is completed more than 3 months before the expiry date of the existing certificate, the new certificate is to be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of completion of the renewal survey.

1.4.6.3 If a certificate is issued for a period of less than 5 years, IRS may extend the validity of the certificate beyond the expiry date to the maximum period specified in 1.4.6.1, provided that the surveys referred to in 1.4.2.3 and 1.4.2.4, applicable when a certificate is issued for a period of 5 years, are carried out as appropriate.

1.4.6.4 If a renewal survey has been completed and a new certificate cannot be issued or placed on board the ship before the expiry date of the existing certificate, IRS may endorse the existing certificate. Such a certificate is to be accepted as valid for a further period which is not to exceed 5 months from the expiry date.

1.4.6.5 If a ship is not in a port in which it is to be surveyed at the time when a certificate expires, IRS may extend the period of validity of the certificate. However, the extension is to be granted only for the purpose of allowing the ship to complete its voyage to the port in which it is to be surveyed and then only in cases where it appears proper and reasonable to do so.

1.4.6.6 A certificate, issued to a ship engaged on short voyages, that has not been extended under the foregoing provisions of this section, may be extended by the Administration for a period of grace of upto one month from the date of expiry stated on it. When the renewal survey is completed, the new certificate shall be valid to a date not exceeding 5 years from the date of expiry of the existing certificate before the extension was granted.

1.4.6.7 In special circumstances, as determined by the Administration, a new certificate need not be dated from the date of expiry of the existing certificate as required by 1.4.6.2.2, 1.4.6.5 or 1.4.6.6. In these special circumstances, the new certificate shall be valid to a date not exceeding 5 years from the date of completion of the renewal survey.

1.4.6.8 If an annual or intermediate survey is completed before the period specified in 1.4.2; then:

.1 the anniversary date shown on the certificate shall be amended by endorsement to a date that is not to be more than 3 months later than the date on which the survey was completed;

.2 the subsequent annual or intermediate survey required by 1.4.2 shall be completed at the intervals prescribed by that section using the new anniversary date;

.3 the expiry date may remain unchanged provided one or more annual or intermediate surveys, as appropriate, are carried out so that the maximum intervals between the surveys prescribed by 1.4.2 are not exceeded.

1.4.6.9 The certificate issued under 1.4.4 or 1.4.5 shall cease to be valid in any of the following cases:

.1 If the relevant surveys are not completed within the periods specified by 1.4.2;

.2 if the certificate is not endorsed in accordance with 1.4.2.3 or 1.4.2.4; and

.2 Upon transfer of the ship to the flag of another State. A new certificate shall only be issued when the Government issuing the new certificate is fully satisfied that the ship is in compliance with the provisions of 1.4.3.1 and 1.4.3.2. In case of transfer between Contracting Governments to the SOLAS Convention, if requested within 3 months after the transfer has taken place, the Government of the State whose flag the ship was formerly entitled to fly shall, as soon as possible, transmit to the Administration copies of the certificates carried by the ship before the transfer and, if available, copies of the relevant survey reports.

IR 1.5 Plans

IR 1.5.1 The plans, to be submitted, are to show clearly that the requirements of this Chapter are fulfilled. Other plans, specifications or information may be required depending on the arrangement and the equipment used in each separate case.

IR 1.5.2 A general arrangement is to be submitted for approval giving location of:

- machinery and boiler spaces, accommodation, service and control station spaces, chain lockers, cofferdams, fuel oil tanks, drinking and domestic water tanks and stores;

- cargo tanks and cargo containment systems;

- cargo pump and compressor rooms;

- cargo control rooms;

- cargo piping with shore connections including stern loading/discharge arrangements and emergency cargo dumping arrangement, if fitted;

- cargo hatches, vent pipes and any other openings to the cargo tanks;

- ventilating pipes, doors and openings to cargo pump rooms, cargo compressor rooms and other gas-dangerous spaces;

- doors, air locks, hatches, ventilating pipes and openings, hinged scuttles which can be opened, and other openings to gas-safe spaces within and adjacent to the cargo area including spaces in and below the forecastle;

- entrances, air inlets and openings to accommodation, service and control station spaces; and

- gas-safe spaces and zones and gas-dangerous spaces and zones to be clearly identified.

IR 1.5.3 Plans of the cargo containment system with the following particulars are to be submitted for approval:

- drawing of cargo tanks including information on non-destructive testing of welds and strength and tightness testing of tanks;

- drawings of support structure of independent tanks;

- drawing of antifloatation arrangement for independent tanks;

- specification of materials in cargo tanks and cargo piping systems;

- specifications of welding procedures for cargo tanks;

- specification of stress relieving procedures for independent tanks Type C (thermal or mechanical);

- specification of design loads and structural analysis of cargo tanks;

- a complete stress analysis is to be submitted for independent tanks, Type B and Type C;

- detailed analytical calculation of hull and tank system for independent tanks, Type B;

- specification of cooling-down procedure for cargo tanks;

- arrangement and specifications of secondary barriers, including method for periodically checking of tightness;

- documentation of model tests of primary and secondary barriers of membrane tanks;

- drawings and specifications of tank insulation; and

- drawing of marking plate for independent tanks.

IR 1.5.4 Plans of the following piping systems are to be submitted for approval:

- drawings and specifications of cargo and process piping including vapour piping and vent lines of safety relief valves or similar piping, and relief valves discharging liquid cargo from the cargo piping system;

- drawings and specifications of offsets, loops, bends and mechanical expansion joints, such as bellows, slip joints (only inside tank) or similar means in the cargo piping;

- drawings and specifications of flanges, valves and other fittings in the cargo piping system. For valves intended for piping systems with a design temperature below -55°C, documentation for leak test and functional test at design temperature (type test) is required;

- complete stress analysis of piping system when design temperature is below -110°C;

- documentation of type tests for expansion components in the cargo piping system;

- specification of materials, welding, post-weld heat treatment and non-destructive testing of cargo piping;

- specification of pressure tests (structural and tightness tests) of cargo and process piping;

- program for functional tests of all piping systems including valves, fittings and associated equipment for handling cargo (liquid or vapour);

- specifications of control system for all quick-closing shut-off valves;

- drawings and specifications and insulation for low temperature piping where such insulation is installed;

- specification of electrical bonding of piping; and

- specification of means for removal of liquid contents from cargo loading and discharging crossover headers and/or cargo hoses prior to disconnecting the shore connection.

IR 1.5.5 The following plans and particulars for the safety relief valves are to be submitted for approval:

- drawings and specifications for safety relief valves and pressure/vacuum relief valves and associated vent piping;

- calculation of required cargo tank relief valve capacity; and

- specification of procedures for changing of set pressures of cargo tank safety relief valves if such arrangements are contemplated.

IR 1.5.6 Plans of the following equipment and systems with particulars are to be submitted:

- construction and specifications of pressure relief systems for hold spaces, interbarrier spaces and cargo piping if such systems are required;

- calculation of hull steel significant temperature when cargo temperature is below -20°C;

- specification of tightness test of hold spaces for membrane tank system;

- arrangement and specifications of means for maintaining the cargo tank vapour pressure below MARVS. (cooling plant, gas burning arrangement, etc.);

- drawings showing location and construction of air locks with alarms equipment;

- drawings of gastight bulkhead stuffing boxes;

- arrangements and specifications of mechanical ventilation systems for spaces in the cargo area, giving capacity and location of fans and their motors. Drawings and material specifications of rotating parts and casings for fans and portable ventilators;

- drawings and specifications of protection of hull steel beneath liquid piping where liquid leakage may be anticipated, such as at shore connections and at pump seals;

- arrangement and specifications of piping system for gas freeing and purging of cargo tanks;

- arrangement of piping for inerting of interbarrier and hold spaces (not required for independent tanks Type C);

- specifications of equipment for provision of dry inert gas (dry air in hold spaces containing independent tanks Type C) for the maintenance of an inert atmosphere in interbarrier and hold spaces;

- specification of instruments for measurement of oxygen content in inert atmospheres;

- arrangement and specifications of all monitoring systems and devices for indicating liquid level, vapour pressure and temperature in the cargo tanks, interbarrier and hold spaces;

- specifications of liquid level alarms;

- arrangement of automatic shut-down of cargo pump and compressors;

- arrangement and specifications of gas detecting equipment;

- location of gas sampling points within cargo tanks;

- bilge and drainage arrangements in cargo pump rooms, cargo compressor rooms, cofferdams, pipe tunnels, hold spaces and interbarrier spaces;

- drawings and specifications of inert gas plants if installed, see Sec. 9; and

- documentation for fire protection, see Sec.11.

IR 1.5.7 Plans of electrical installations giving the following particulars are to be submitted for approval:

- area classification drawing(s);

- drawing(s) showing location of all electrical equipment in gas dangerous area;

- single line diagram for intrinsically safe circuits; and

- list of explosion protected equipment with reference to drawings together with certificates.

Section 2

Ship Survival Capability and Location of Cargo Tanks

2.0 Goal

To ensure that the cargo tanks are in a protective location in the event of minor hull damage, and that the ship can survive the assumed flooding conditions.

2.1 General

2.1.1 Ships subject to this chapter are to survive the hydrostatic effects of flooding following assumed hull damage caused by some external force. In addition, to safeguard the ship and the environment, the cargo tanks are to be protected from penetration in the case of minor damage to the ship resulting, for example, from contact with a jetty or tug, and also given a measure of protection from damage in the case of collision or grounding, by locating them at specified minimum distances inboard from the ship's shell plating. Both the damage to be assumed and the proximity of the tanks to the ship's shell are to be dependent upon the degree of hazard presented by the product to be carried. In addition, the proximity of the cargo tanks to the ship’s shell is to be dependent upon the volume of the cargo tank.

2.1.2 Ships subject to this chapter are to be designed to one of the following standards:

- **A Type 1G ship** is a gas carrier intended to transport the products indicated in Sec.19 that require maximum preventive measures to preclude their escape.

- **A Type 2G ship** is a gas carrier intended to transport the products indicated in Sec.19 that require significant preventive measures to preclude their escape.

- **A Type 2PG ship** is a gas carrier of 150 [m] in length or less intended to transport the products indicated in Sec.19 that require significant preventive measures to preclude their escape, and where the products are carried in Type C independent tanks (refer 4.23) designed for a MARVS of at least 7.0 bar gauge and a cargo containment system design temperature of -55°C or above. A ship of this description that is over 150 [m] in length is considered a Type 2G ship;

- **A Type 3G ship** is a gas carrier intended to carry products indicated in Sec.19 that require moderate preventive measures to preclude their escape.

Therefore, a type 1G ship is a gas carrier intended for the transportation of products considered to present the greatest overall hazard and types 2G/2PG and type 3G for products of progressively lesser hazards. Accordingly, a type 1G ship is to survive the most severe standard of damage and its cargo tanks are to be located at the maximum prescribed distance inboard from the shell plating.

2.1.3 The ship type required for individual products is indicated in column "c" in Table 19.1.1 of Sec.19.

2.1.4 If a ship is intended to carry more than one of the products listed in Sec.19, the standard of damage is to correspond to the product having the most stringent ship type requirements. The requirements for the location of individual cargo tanks, however, are those for ship types related to the respective products intended to be carried.

2.1.5 For the purpose of this chapter, the position of the moulded line for different containment systems is shown in Fig.2.1.5 (a) to (e).

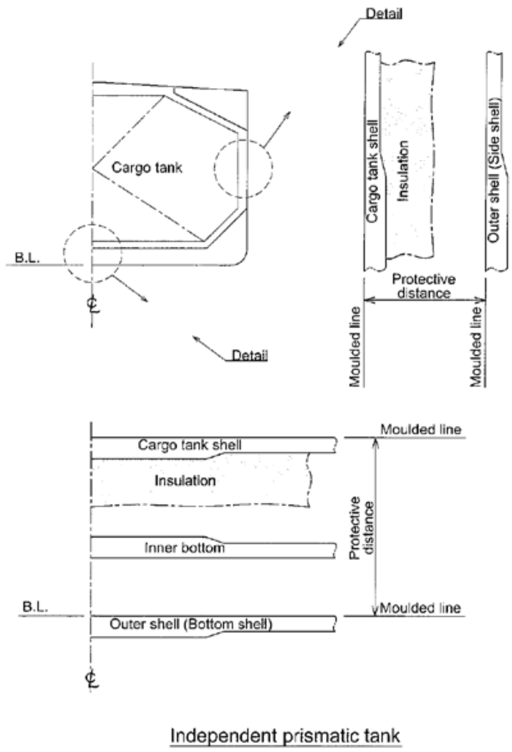


Fig 2.1.5 (a)

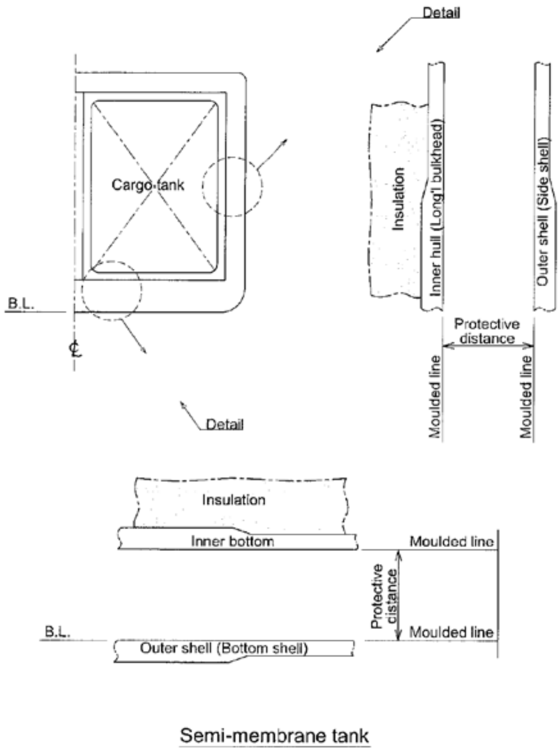
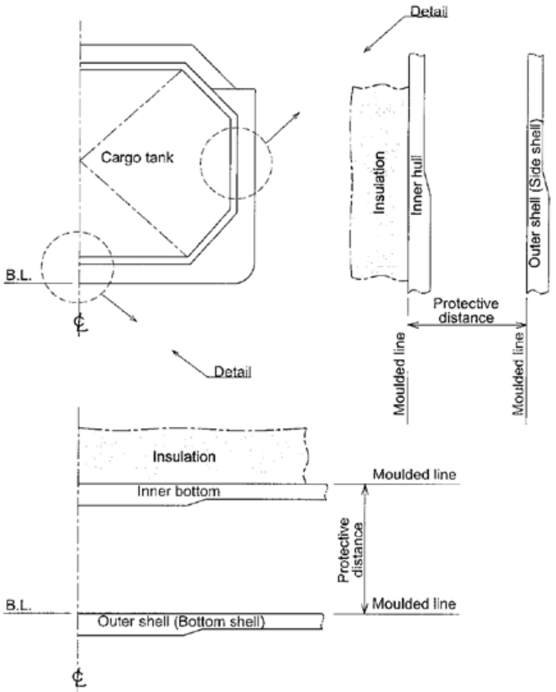
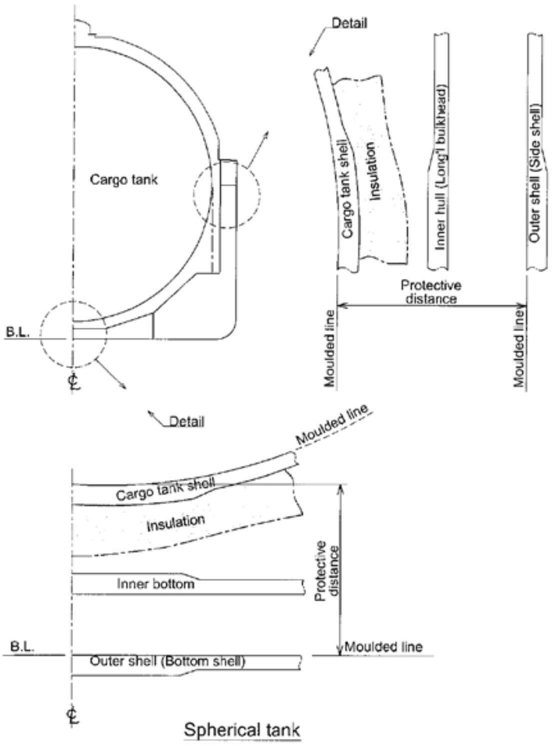


Fig 2.1.5 (b)



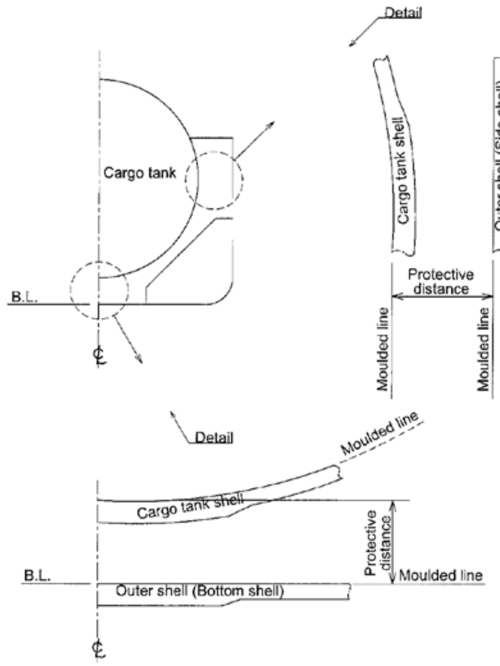
Membrane tank

Fig 2.1.5 (c)



Spherical tank

Fig 2.1.5 (d)



Pressure type tank

Fig 2.1.5 (e)

2.2 Freeboard and stability

2.2.1 Ships subject to this chapter may be assigned the minimum freeboard permitted by the International Convention on Load Lines, in force. However the draught associated with the assignment is not to be greater than the maximum draught otherwise permitted by this chapter.

2.2.2 The stability of the ship, in all seagoing conditions and during loading and unloading cargo is to comply with the requirements of the International Code on Intact Stability. This includes partial filling and loading and unloading at sea, when applicable. Stability during ballast water operations is to fulfill stability criteria.

2.2.3 When calculating the effect of free surfaces of consumable liquids for loading conditions it is to be assumed that for each type of liquid, at least one transverse pair or a single centre tank has a free surface. The tank or combination of tanks to be taken into account are to be those where the effect of free surfaces is greatest. The free surface effect in undamaged compartments is to be calculated by a method according to the International Code on Intact Stability.

2.2.4 Solid ballast is not normally to be used in double bottom spaces in the cargo area. Where, however, because of stability considerations the fitting of solid ballast in such spaces becomes unavoidable, its disposition is to be governed by the need to enable access for inspection and to ensure that the impact loads resulting from bottom damage are not directly transmitted on to the cargo tank structure.

2.2.5 The master of the ship is to be supplied with a Loading and Stability Information booklet. This booklet is to contain details of typical service conditions, loading, unloading and ballasting operations, provisions for evaluating other conditions of loading and a summary of the ship's survival capabilities. The booklet is to contain sufficient information to enable the master to load and operate the ship in a safe and seaworthy manner.

2.2.6 All ships, subject to this chapter shall be fitted with a stability instrument, capable of verifying compliance with intact and damage stability requirements, approved by IRS having regard to the performance standards recommended by the Organization.

.1 ships constructed before 1 July 2016 shall comply with this paragraph at the first scheduled renewal survey of the ship after 1 July 2016 but not later than 1 July 2021;

.2 notwithstanding the requirements of paragraph 2.2.6.1 a stability instrument installed on a ship constructed before 1 July 2016 need not be replaced provided it is capable of verifying compliance with intact and damage stability, to the satisfaction of the Administration; and

.3 for the purposes of control under SOLAS regulation XI-1/4, IRS would issue a document of approval for the stability instrument.

2.2.7 The Administration may waive the requirements of paragraph 2.2.6 for the following ships, provided the procedures employed for intact and damage stability verification maintain the same degree of safety, as being loaded in accordance with the approved conditions. Any such waiver shall be duly noted on the International Certificate of Fitness referred to in paragraph 1.4.4:

.1 ships which are on a dedicated service, with a limited number of permutations of loading such that all anticipated conditions have been approved in the stability information provided to the master in accordance with the requirements of paragraph 2.2.5;

.2 ships where stability verification is made remotely by a means approved by the Administration/ IRS;

.3 ships which are loaded within an approved range of loading conditions; or

.4 ships constructed before 1 July 2016 provided with approved limiting KG/GM curves covering all applicable intact and damage stability requirements

2.2.8 Conditions of loading

Damage survival capability is to be investigated on the basis of loading information submitted to IRS for all anticipated conditions of loading and variations in draught and trim. This is to include ballast and, where applicable, cargo heel.

2.3 Damage assumptions

2.3.1 The assumed maximum extent of damage is to be:

.1 Side damage	
Direction	**Extent Of Damage**
.1.1 Longitudinal extent	$\frac{1}{3}L^{2/3}$ or 14.5 [m], whichever is less
.1.2Transverse extent : measured inboard from the moulded line of the outer shell at right angles to the centreline at the level of the summer waterline	B/5 or 11.5 [m], whichever is less
.1.3 Vertical extent : from the moulded line of the outer shell	upwards without limit

.2 Bottom damage		
Direction	**For 0.3L from the forward perpendicular of the ship**	**Any other part of the ship**
.2.1 Longitudinal extent	$\frac{1}{3}L^{2/3}$ or 14.5 [m], whichever is less	$\frac{1}{3}L^{2/3}$ or 14.5 [m], whichever is less
.2.2 Transverse extent	B/6 or 10 [m], whichever is less	B/6 or 5 [m], whichever is less
.2.3 Vertical extent	B/15 or 2 [m], whichever is less, measured from the moulded line of the bottom shell plating at centreline (see 2.4.3)	B/15 or 2 [m], whichever is less, measured from the moulded line of the bottom shell plating at centreline (see 2.4.3)

2.3.2 Other damage:

2.3.2.1 If any damage of lesser extent than the maximum damage specified in 2.3.1 would result in a more severe condition, such damage is to be assumed.

2.3.2.2 Local damage anywhere in the cargo area extending inboard distance "d" as defined in 2.4.1 measured normal to the moulded line of the outer shell is to be considered. Bulkheads are to be assumed damaged when the relevant sub-paragraphs of 2.6.1 apply. If a damage of a lesser extent than "d" would result in a more severe condition, such damage is to be assumed.

2.4 Location of cargo tanks

2.4.1 Cargo tanks are to be located at the following distances inboard:

.1 **Type 1G ships**: from the moulded line of the outer shell, not less than the transverse extent of damage specified in 2.3.1.1.2 and, from the moulded line of the bottom shell at centerline, not less than the vertical extent of damage specified in 2.3.1.2.3 and nowhere less than “d” where “d” is as follows:

.1) for Vc below or equal 1000 [m^3], d=0.8 [m];

.2) for 1000 [m^3] < Vc < 5000 [m^3], d=0.75 + Vc x 0.2/4000 [m];

.3) for 5000 [m^3] ≤ Vc < 30000 [m^3], d = 0.8 + Vc/25000 m and

.4) for Vc ≥ 30000 m^3, d=2 [m]

Where:

Vc corresponds to 100% of the gross design volume of the individual cargo tank at 20 [deg C], including domes and appendages (see the Fig.2.4.1 (a) and (b)). For the purpose of cargo tank protective distances, the cargo tank volume is the aggregate volume of all the parts of tank that have a common bulkhead(s); and

“d” is measured at any cross section at a right angle from the moulded line of outer shell.

Tank size limitation may apply to type 1G ship cargoes in accordance with section 17.

.2 **Types 2G/2PG** : from the moulded line of the bottom shell at centreline not less than the vertical extent of damage specified in 2.3.1.2.3 and nowhere less than “d” as indicated in 2.4.1.1 (see Fig.2.4.1 (a) and (c))

.3 **Type 3G Ships**: from the moulded line of the bottom shell at centerline not less than the vertical extent of damage specified in 2.3.1.2.3 and nowhere less than “d”, where “d” = 0.8 [m] from moulded line of outer shell. (see Figs.2.4.1 (a) and (d))

2.4.2 For the purpose of tank location, the vertical extent of bottom damage is to be measured to the inner bottom when membrane or semi-membrane tanks are used, otherwise to the bottom of the cargo tanks. The transverse extent of side damage is to be measured to the longitudinal bulkhead when membrane or semi-membrane tanks are used, otherwise to the side of the cargo tanks. The distance indicated in 2.3 and 2.4 is to be applied as in Figs.2.1.5 (a) to (e). These distances is to be measured plate to plate, from the moulded line to the moulded line, excluding insulation.

2.4.3 Except for Type 1G ships, suction wells installed in cargo tanks may protrude into the vertical extent of bottom damage specified in 2.3.1.2.3 provided that such wells are as small as practicable and the protrusion below the inner bottom plating does not exceed 25 per cent of the depth of the double bottom or 350 [mm], whichever is less. Where there is no double bottom, the protrusion below the upper limit of bottom damage is not to exceed 350 mm. Suction wells installed in accordance with this paragraph may be ignored in determining the compartments affected by damage.

2.4.4 Cargo tanks are not to be located forward of the collision bulkhead.

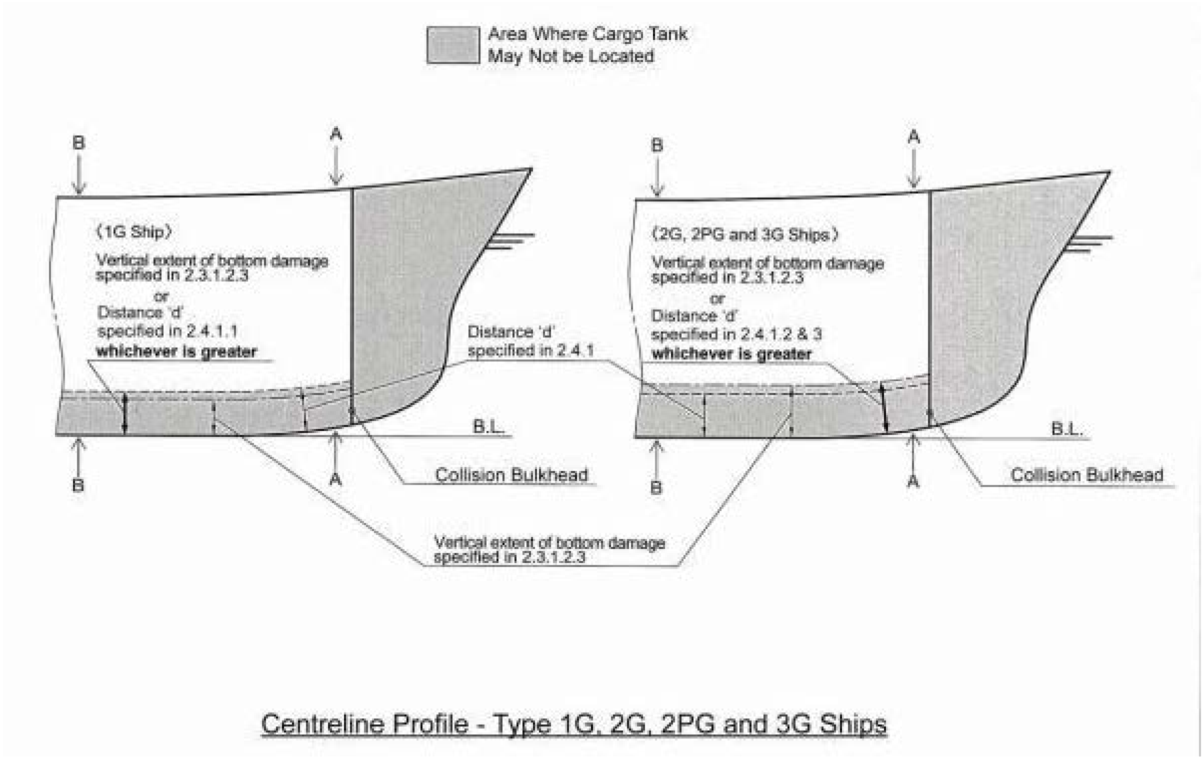


Fig.2.4.1 (a) : Cargo tank location requirements

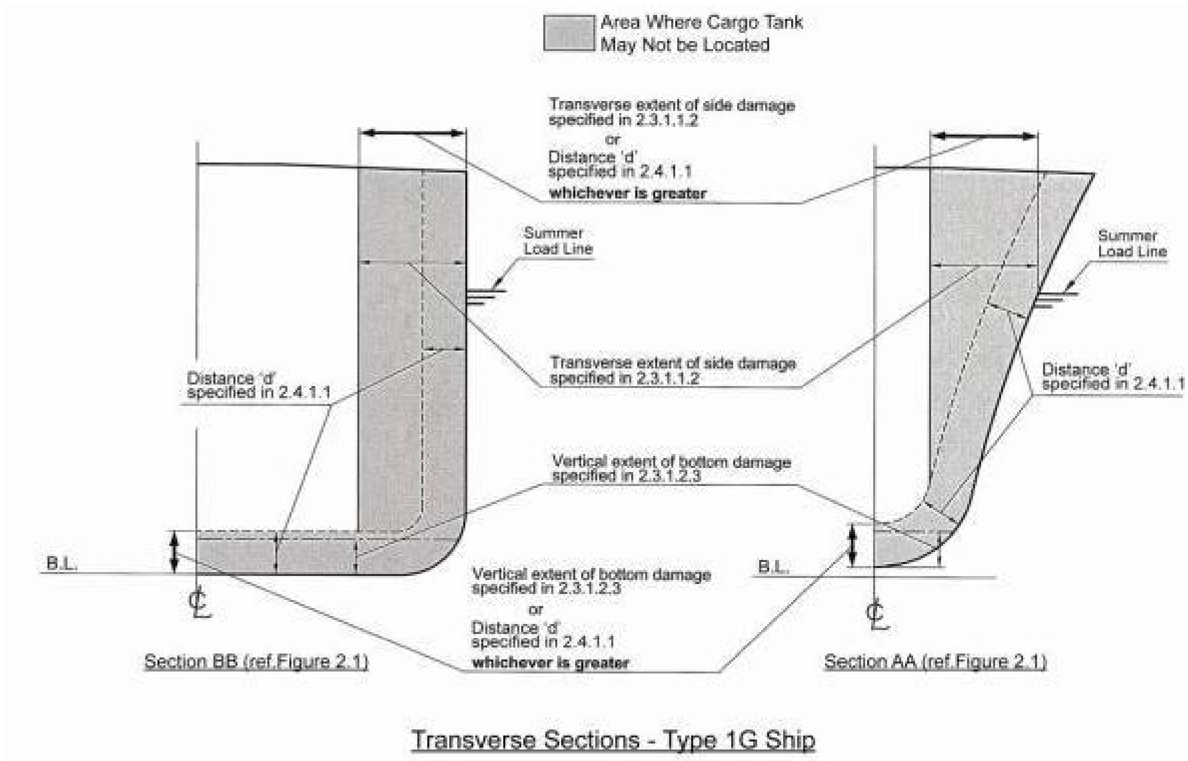


Fig.2.4.1 (b) : Cargo tank location requirements

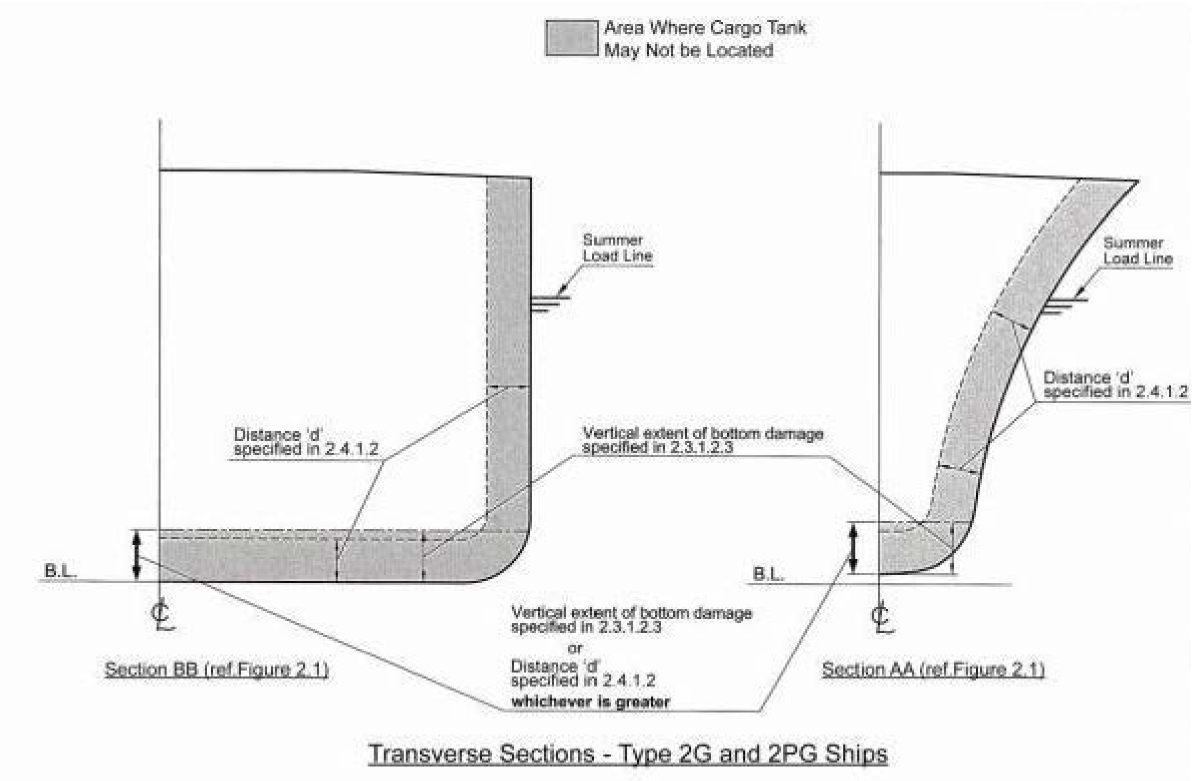


Fig.2.4.1 (c) : Cargo tank location requirements

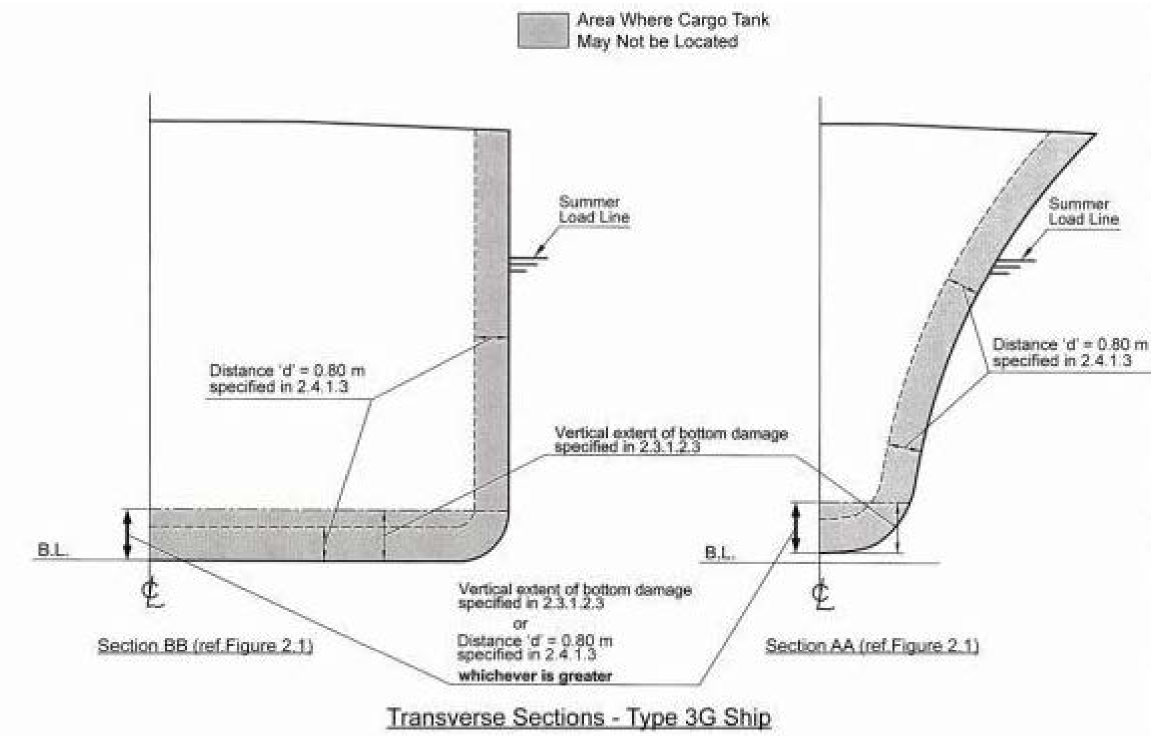


Fig.2.4.1 (d) : Cargo tank location requirements

2.5 Flooding assumptions

2.5.1 The requirements of 2.7 are to be confirmed by calculations that take into consideration the design characteristics of the ship; the arrangements, configuration and contents of the damaged compartments; the distribution, relative densities and the free surface effects of liquids; and the draught and trim for all conditions of loading.

2.5.2 The permeabilities of spaces assumed to be damaged are to be as follows:

Spaces	Permeabilities
stores	0.60
Accommodation	0.95
Machinery	0.85
Voids	0.95
Hold spaces	0.95**
Consumable liquids	0 to 0.95*
Other liquids	0 to 0.95*
* The permeability of partially filled compartments is to be consistent with the amount of liquid carried. ** Other values of permeability can be considered based on the detailed calculations. Interpretations of regulation of part B-1 of SOLAS Chapter II-1 (MSC/Circ.651) are referred.	

2.5.3 Wherever damage penetrates a tank containing liquids, it is to be assumed that the contents are completely lost from that compartment and replaced by salt water up to the level of the final plane of equilibrium.

2.5.4 Where the damage between transverse watertight bulkheads is envisaged as specified in 2.6.1.4, .5, and .6, transverse bulkheads are to be spaced at least at a distance equal to the longitudinal extent of damage specified in 2.3.1.1.1 in order to be considered effective. Where transverse bulkheads are spaced at a lesser distance, one or more of these bulkheads within such extent of damage are to be assumed as non-existent for the purpose of determining flooded compartments. Further, any portion of a transverse bulkhead bounding side compartments or double bottom compartments is to be assumed damaged if the watertight bulkhead boundaries are within the extent of vertical or horizontal penetration required by 2.3. Also, any transverse bulkhead is to be assumed damaged if it contains a step or recess of more than 3 [m] in length located within the extent of penetration of assumed damage. The step formed by the after peak bulkhead and after peak tank top is not to be regarded as a step for the purpose of this paragraph.

2.5.5 The ship is to be so designed as to keep unsymmetrical flooding to the minimum consistent with efficient arrangement.

2.5.6 Equalization arrangements requiring mechanical aids such as valves or cross-leveling pipes, if fitted, are not to be considered for the purpose of reducing an angle of heel or attaining the minimum range of residual stability to meet the requirements of 2.7.1 and sufficient residual stability is to be maintained during all stages where equalization is used. Spaces linked by ducts of large cross-sectional area may be considered to be common.

2.5.7 If pipes, ducts, trunks or tunnels are situated within the assumed extent of damage penetration, as defined in 2.3, arrangements are to be such that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage.

2.5.8 The buoyancy of any superstructure directly above the side damage is to be disregarded. However, the unflooded parts of superstructures beyond the extent of damage, however, may be taken into consideration provided that:

.1 they are separated from the damaged space by watertight divisions and the requirements of 2.7.1.1 in respect of these intact spaces are complied with; and

.2 openings in such divisions are capable of being closed by remotely operated sliding watertight doors and unprotected openings are not immersed within the minimum range of residual stability required in 2.7.2.1. However, the immersion of any other openings capable of being closed weathertight may be permitted.

2.6 Standard of damage

2.6.1 Ships are to be capable of surviving the damage indicated in 2.3 with the flood assumptions in 2.5, to the extent determined by the ship's type according to the following standards:

.1 A Type 1G ship is to be assumed to sustain damage anywhere in its length;

.2 A Type 2G ship of more than 150 [m] in length is to be assumed to sustain damage anywhere in length;

.3 A Type 2G ship of 150 [m] in length or less is to be assumed to sustain damage anywhere in its length except involving either of the bulkheads bounding a machinery space located aft;

.4 A Type 2PG ship it to be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage as specified in 2.3.1.1.1;

.5 A Type 3G ship of 80 [m] in length or more is to be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in 2.3.1.1.1;

.6 A Type 3G ship less than 80 [m] in length is to be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in 2.3.1.1.1 and except damage involving the machinery space when located aft.

2.6.2 In the case of small Type 2G/2PG and 3G ships that do not comply in all respects with the appropriate requirements of 2.6.1.3,.4 and .6, special dispensations may only be considered by the Administration provided that alternative measures can be taken which maintain the same degree of safety. The nature of the alternative measures are to be approved and clearly stated and be available to the port Administration. Any such dispensation will be duly noted on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk referred to in 1.4.4.

2.7 Survival requirements

Ships subject to this Chapter are to be capable of surviving the assumed damage specified in 2.3, to the standard provided in 2.6 in a condition of stable equilibrium and are to satisfy the following criteria.

2.7.1 In any stage of flooding:

.1 the waterline, taking into account sinkage, heel and trim, is to be below the lower edge of any opening through which progressive flooding or downflooding may take place. Such openings are to include air pipes and openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers that maintain the high integrity of the deck, remotely operated watertight sliding doors, and sidescuttles of the non-opening type;

.2 the maximum angle of heel due to unsymmetrical flooding is not to exceed 30 [deg]; and

.3 the residual stability during intermediate stages of flooding is not to be less than that required by 2.7.2.1.

2.7.2 At final equilibrium after flooding:

.1 the righting lever curve is to have a minimum range of 20 [deg] beyond the position of equilibrium in association with a maximum residual righting lever of at least 0.1 [m] within the 20 [deg] range; the area under the curve within this range is not to be less than 0.0175 [m-radians] The 20 [deg] range may be measured from any angle commencing between the position of equilibrium and the angle of 25 [deg] (or 30 [deg] if no deck immersion occurs) Unprotected openings are not to be immersed within this range unless the space concerned is assumed to be flooded. Within this range, the immersion of any of the openings listed in 2.7.1.1 and other openings capable of being closed weathertight may be permitted; and

.2 the emergency source of power is to be capable of operating.

Section 3

Ship Arrangements

3.0 Goal

To ensure that the cargo containment and handling system are located such that the consequences of any release of cargo will be minimized, and to provide safe access for operation and inspection.

3.1 Segregation of the cargo area

3.1.1 Hold spaces are to be segregated from machinery and boiler spaces, accommodation spaces, service spaces, control station, chain lockers, domestic water tanks and from stores. Hold spaces are to be located forward of machinery spaces of category 'A'. Alternative arrangements, including locating machinery spaces of category A forward, may be accepted, based on SOLAS regulation II-2/17(Pt 6, Ch 6), after further consideration of involved risks, including that of cargo release and the means of mitigation.

3.1.2 Where cargo is carried in a cargo containment system not requiring a complete or partial secondary barrier, segregation of hold spaces from spaces referred to in 3.1.1 or spaces either below or outboard of the hold spaces may be effected by cofferdams, fuel oil tanks, or a single gastight bulkhead of all welded construction forming an A-60 Class division. A gas-tight A-0 Class division is acceptable if there is no source of ignition or fire hazard in the adjoining spaces.

3.1.3 Where cargo is carried in a cargo containment system requiring a complete or partial secondary barrier, segregation of hold spaces from spaces referred to in 3.1.1 or spaces either below or outboard of the hold spaces that contain a source of ignition or fire hazard is to be effected by cofferdams or fuel oil tanks. A gastight A-0 class division is acceptable if there is no source of ignition or fire hazard in the adjoining spaces.

3.1.4 Turret compartment segregation from spaces referred in 3.1.1, or spaces either below or outboard of the turret compartment that contain a source of ignition or fire hazard, are to be effected by cofferdams or an A-60 class division. A gastight A-0 class division is acceptable if there is no source of ignition or fire hazard in the adjoining spaces.

3.1.5 In addition, the risk of fire propagation from turret compartments to adjacent spaces are to be evaluated by risk analysis (see 1.1.11) and further preventive measures, such as the arrangement of a cofferdam around the turret compartment, is to be provided if need.

3.1.6 When cargo is carried in a cargo containment system requiring a complete or partial secondary barrier:

.1 at temperatures below -10°C, hold spaces are to be segregated from the sea by a double bottom, and

.2 at temperatures below -55°C, the ship is to also have a longitudinal bulkhead forming side tanks.

3.1.7 Arrangements are to be made for sealing the weather decks in way of openings for cargo containment systems.

3.2 Accommodation, service and machinery spaces and control stations

3.2.1 No accommodation space, service space or control station is to be located within the cargo area. The bulkhead of accommodation spaces, service spaces or control stations that face the cargo area is to be so located as to avoid the entry of gas from the hold space to such spaces through a single failure of a deck or bulkhead on a ship having a containment system requiring a secondary barrier.

3.2.2 To guard against the danger of hazardous vapours, due consideration is to be given to the location of air intakes/outlets and openings into accommodation, service and machinery spaces and control stations in relation to cargo piping, cargo vent systems and machinery space exhausts from gas burning arrangements.

3.2.3 Access through doors, gastight or otherwise, is not to be permitted from a non-hazardous area to a hazardous area , except for access to service spaces forward of the cargo area through air-locks as permitted by 3.6.1 when accommodation spaces are aft.

3.2.4.1 Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and control stations are not to face the cargo area. They are to be located on the end bulkhead not facing the cargo area or on the outboard side of the superstructure or deckhouse or on both at a distance of at least 4 percent of the length of the ship but not less than 3 [m] from the end of the superstructure or deck-house facing the cargo area. This distance, however, need not exceed 5 [m].

3.2.4.2 Windows and side scuttles facing the cargo area and on the sides of the superstructures or deckhouses within the distance mentioned above are to be of the fixed (non-opening) type. Wheelhouse windows may be non-fixed and wheelhouse doors may be located within the above limits so long as they are designed in a manner that a rapid and efficient gas and vapour tightening of the wheelhouse can be ensured.

3.2.4.3 For ships dedicated to the carriage of cargoes that have neither flammable nor toxic hazards, IRS may approve relaxations from the above requirements.

3.2.4.4 Access to forecastle spaces containing sources of ignition may be permitted through a single door facing cargo area, provided the doors are located outside hazardous areas as defined in Sec 10.

3.2.5 Windows and side scuttles facing the cargo area and on the sides of the superstructures and deckhouses within the limits specified in 3.2.4, except wheelhouse windows, are to be constructed to "A-60" class. Wheelhouse windows are to be constructed to not less than "A-0" class (for external fire load).Side scuttles in the shell below the uppermost continuous deck and in the first tier of the superstructure are to be of the fixed (non-opening) type.

3.2.6 All air intakes, outlets and other openings into the accommodation spaces, service spaces and control stations are to be fitted with closing devices. When carrying toxic products, they are to be capable of being operated from inside the space. The requirement for fitting air intakes and openings with closing devices operated from inside the space for toxic products need not apply to spaces not normally manned, such as deck stores, forecastle stores, workshops. In addition, the requirement does not apply to cargo control rooms located within the cargo area.

IR 3.2.6.1 The closing devices need not be operable from within the single spaces and may be located in centralized positions. Engine room casings, cargo machinery spaces, electric motor rooms and steering gear compartments are generally considered as spaces not covered by 3.2.6 and therefore the requirement for closing devices not to be applied to these spaces.

IR 3.2.6.2 The closing devices are to give a reasonable degree of gas tightness. Ordinary steel fire-flaps without gaskets/seals are not to be considered satisfactory.

3.2.7 Control rooms and machinery spaces of turret systems may be located in the cargo area forward or aft of cargo tanks in ships with such installations. Access to such spaces containing sources of ignition may be permitted through doors facing the cargo area, provided the doors are located outside hazardous areas or access is through airlocks.

3.3 Cargo machinery spaces and turret compartments

3.3.1 Cargo machinery spaces are to be situated above the weather deck and located within the cargo area. Cargo machinery spaces and turret compartments are to be treated as cargo pump rooms for the purpose of fire protection according to SOLAS regulation II-2/9.2.4 (Rules Pt.6, Ch.3, Cl.3.2.4), and for the prevention of potential explosion according to SOLAS regulation II-2/4.5.10 (Pt 6, Ch 2, 1.5.10).

3.3.2 When cargo machinery spaces are located at the after end of the aftermost hold space or at the forward end of the foremost hold space, the limits of the cargo area as defined is 1.2.7 are to be extended to include the cargo machinery spaces for the full breadth and depth of the ship and deck areas above those spaces.

3.3.3 Where the limits of the cargo area are extended by 3.3.2, the bulkhead that separates the cargo machinery spaces from accommodation and service spaces, control stations and machinery spaces of category 'A' are to be located so as to avoid the entry of gas to these spaces through a single failure of a deck or bulkhead.

3.3.4 Cargo compressors and cargo pumps may be driven by electric motors in an adjacent non-hazardous space separated by a bulkhead or deck, if the seal around the bulkhead penetration ensures effective gastight segregation of the two spaces. Alternatively, such equipment may be driven by certified safe electric motors adjacent to them if the electrical installation complies with the requirements of Sec 10.

3.3.5 Arrangements of cargo machinery spaces and turret compartments are to be such as to ensure safe unrestricted access for personnel wearing protective clothing and breathing apparatus, and in the event of injury to allow unconscious personnel to be removed. At least two widely separated escape routes and doors shall be provided in cargo machinery spaces, except that a single escape route may be accepted where the maximum travel distance to the door is 5 [m] or less.

3.3.6 All valves necessary for cargo handling are to be readily accessible to personnel wearing protective clothing. Suitable arrangements are to be made to deal with drainage of pump and compressor rooms.

3.3.7 Turret compartments are to be designed to retain their structural integrity in case of explosion or uncontrolled high-pressure gas release (overpressure and/or brittle fracture), the characteristics of which are to be substantiated on the basis of a risk analysis with due consideration of the capabilities of the pressure relieving devices.

3.4 Cargo control rooms

3.4.1 Any cargo control room is to be above the weather deck and may be located in the cargo area. The cargo control room may be located within the accommodation spaces, service spaces or control station provided the following conditions are complied with:

.1 The cargo control room is a non-hazardous area

.2 If the entrance complies with 3.2.4.1, the control room may have access to the spaces described above; and

.3 If the entrance does not comply with 3.2.4.1, the control room is to have no access to the spaces described above and the boundaries to such spaces are to be insulated to "A-60" class.

3.4.2 If the cargo control room is designed to be a non-hazardous area, instrumentation is, as far as possible, to be by indirect reading systems and is in any case to be designed to prevent any escape of gas into the atmosphere of that space. Location of the gas detection system within the cargo control room will not cause the room to be classified as a hazardous area, if installed in accordance with 13.6.11.

3.4.3 If the cargo control room for ships carrying flammable cargoes is classified as a hazardous area, sources of ignition are to be excluded and any electrical equipment is to be installed in accordance with sec 10.

3.5 Access to spaces in the cargo area

3.5.1 Visual inspection of at least one side of the inner hull structure is to be possible without the removal of any fixed structure or fitting. If such a visual inspection, whether combined with those inspections required in 3.5.2, 4.6.2.4 or 4.20.3.7 or not, is only possible at the outer face of the inner hull, the inner hull is not to be a fuel-oil tank boundary wall.

3.5.2 Inspection of one side of any insulation in hold spaces is to be possible. If the integrity of the insulation system can be verified by inspection of the outside of the hold space boundary when tanks are at service temperature, inspection of one side of the insulation in the hold space need not be required.

3.5.3 Arrangements for hold spaces, void spaces, cargo tanks and other spaces classified as hazardous areas, are to be such as to allow entry and inspection of any such space by personnel wearing protective clothing and breathing apparatus and are to also allow for the evacuation of injured and/or unconscious personnel. Such arrangements are to comply with the following:

.1 Access are to be provided as follows:

.1 access to all cargo tanks. Access is to be direct from the weather deck;

.2 access through horizontal openings¸ hatches or manholes. The dimensions are to be sufficient to allow a person wearing a breathing apparatus to ascend or descend any ladder without obstruction, and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space. The minimum clear opening is to be not less than 600 [mm] x 600 [mm];

IR.2 The minimum clear opening of 600 [mm] X 600 [mm] may have corner radii up to 100 [mm] maximum. In such a case where as a consequence of structural analysis of a given design the stress is to be reduced around the opening, it is considered appropriate to take measures to reduce the stress such as making the opening larger with increased radii, e.g. 600 [mm] X 800 [mm] with corner radii up to 100 [mm] maximum fits.

.3 access through vertical openings or manholes providing passage through the length and breadth of the space. The minimum clear opening is to be not less than 600 [mm] x 800 [mm] at a height of not more than 600 [mm] from the bottom plating unless gratings or other footholds are provided; and

IR.3.1 The minimum clear opening of not less than 600 [mm] X 800 [mm] may also include an opening with corner radii of 300 [mm]. An opening of 600 [mm] in height and 800 [mm] in width may be accepted as access openings in vertical structures where it is not desirable to make large opening in the structural strength aspects, i.e. girders and floors in double bottom tanks. (Refer to Figure 3.5.3.1)

IR.3.2 Subject to verification of easy evacuation of injured person on a stretcher the vertical opening 850 [mm] X 620 [mm] with wider upper half than 600 [mm], while the lower half may be less than 600 [mm] with the overall height not less than 850 [mm] is considered an acceptable alternative to the traditional opening of 600 [mm] X 800 [mm] with corner radii of 300 [mm]. (Refer to figure 3.5.3.2)

IR.3.3 If a vertical opening is at a height of more than 600 [mm], steps an handgrips are to be provided. In such arrangements it is to be demonstrated that an injured person can be easily evacuated.

.4 circular access openings to type C tanks are to have a diameter of not less than 600 [mm].

.2 The dimensions referred to in 3.5.3.1.2 and 3.5.3.1.3 may be decreased, if the requirements of 3.5.3 can be met to the satisfaction of the IRS.

.3 Where cargo is carried in a containment system requiring a secondary barrier, the requirements of 3.5.3.1.2 and 3.5.3.1.3 do not apply to spaces separated from a hold space by a single gastight steel boundary. Such spaces are to be provided only with direct or indirect access from the weather deck, not including any enclosed non-hazardous area.

.4 Access required for inspection are to be a designated access through structures below and above cargo tanks, which are to have at least the cross-sections as required by 3.5.3.1.3.

.5 For the purpose of 3.5.1 or 3.5.2, the following applies:

.1 where it is required to pass between the surface to be inspected, flat or curved, and structures such as deck beams, stiffeners, frames, girders, etc., the distance between that surface and the free edge of the structural elements is to be at least 380 [mm]. The distance between the surface to be inspected and the surface to which the above structural elements are fitted, e.g. deck, bulkhead or shell, is to be at least 450 [mm] for a curved tank surface (e.g. for a type C tank), or 600 [mm] for a flat tank surface (e.g. for a type A tank) (see Fig.3.1);

.2 where it is not required to pass between the surface to be inspected and any part of the structure, for visibility reasons the distance between the free edge of that structural element and the surface to be inspected is to be at least 50 [mm] or half the breadth of the structure's face plate, whichever is the larger (see Fig.3.2);

.3 if for inspection of a curved surface where it is required to pass between that surface and another surface, flat or curved, to which no structural elements are fitted, the distance between both surfaces are to be at least 380 [mm] (see Fig.3.3). Where it is not required to pass between that curved surface and another surface, a smaller distance than 380 [mm] may be accepted taking into account the shape of the curved surface;

.4 if for inspection of an approximately flat surface where it is required to pass between two approximately flat and approximately parallel surfaces, to which no structural elements are fitted, the distance between those surfaces is to be at least 600 [mm]. Where fixed access ladders are fitted, a clearance of at least 450 [mm] is to be provided for access (see Fig.3.4);

.5 the minimum distances between a cargo tank sump and adjacent double bottom structure in way of a suction well is not to be less than those shown in Fig.3.5 (Fig.3.5 shows that the distance between the plane surfaces of the sump and the well is a minimum of 150 [mm] and that the clearance between the edge between the inner bottom plate, and the vertical side of the well and the knuckle point between the spherical or circular surface and sump of the tank is at least 380 [mm]). If there is no suction well, the distance between the cargo tank sump and the inner bottom is not to be less than 50 [mm];

.6 the distance between a cargo tank dome and deck structures is not to be less than 150 [mm] (see Fig.3.6);

.7 fixed or portable staging is to be installed as necessary for inspection of cargo tanks, cargo tank supports and restraints (e.g. anti-pitching, anti-rolling and anti-flotation chocks), cargo tank insulation etc. This staging are not to impair the clearances specified in 3.5.3.5.1 to 3.5.3.5.4; and

.8 if fixed or portable ventilation ducting are to be fitted in compliance with 12.1.2, such ducting are not to impair the distances required under 3.5.3.5.1 to 3.5.3.5.4.

3.5.4 Access from the open weather deck to non-hazardous areas is to be located outside the hazardous areas as defined in Sec 10, unless the access is by means of an airlock in accordance with 3.6.

3.5.5 Turret compartments are to be arranged with two independent means of access/egress.

3.5.6 Access from a hazardous area below the weather deck to a non-hazardous area is not permitted.

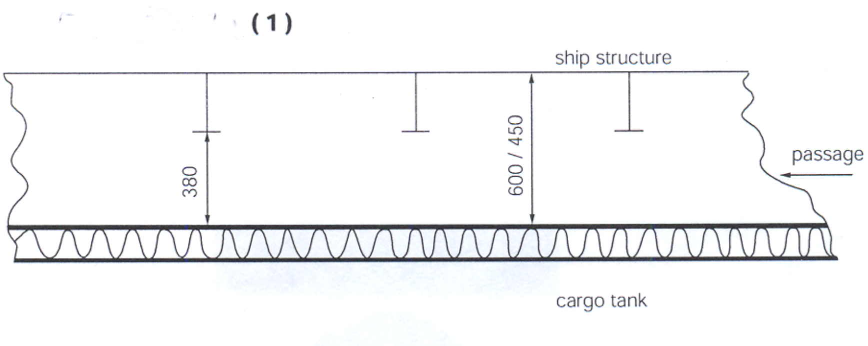


Fig.3.5.2(1)

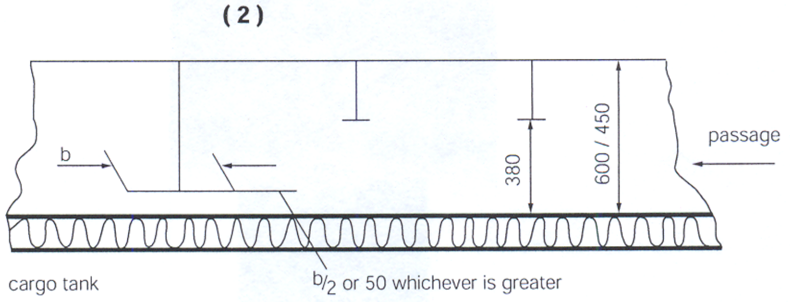
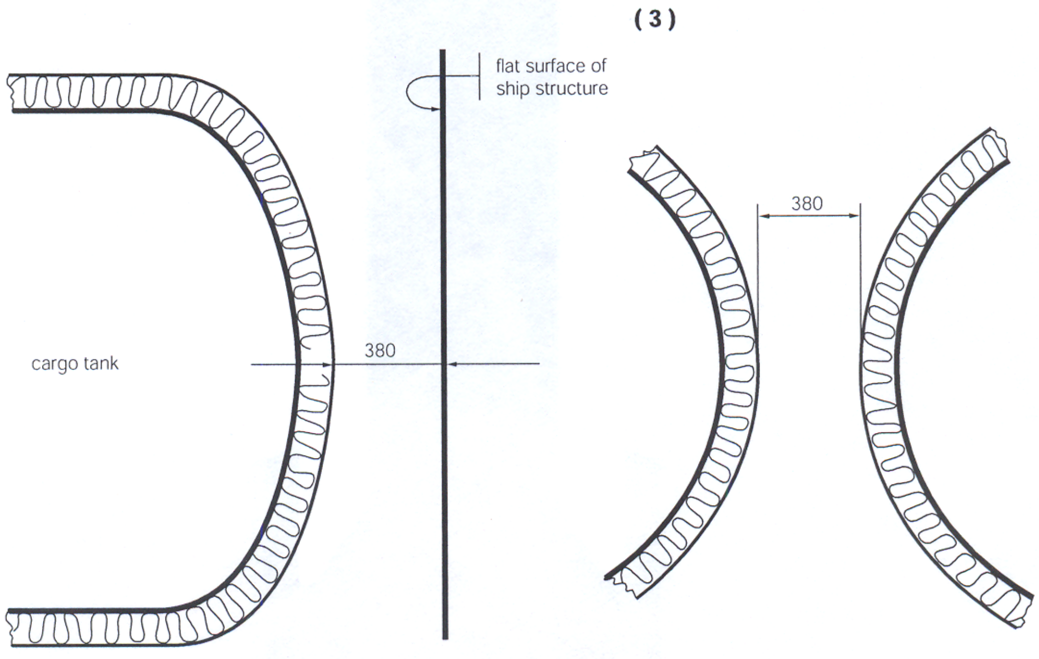


Fig.3.5.2(2)



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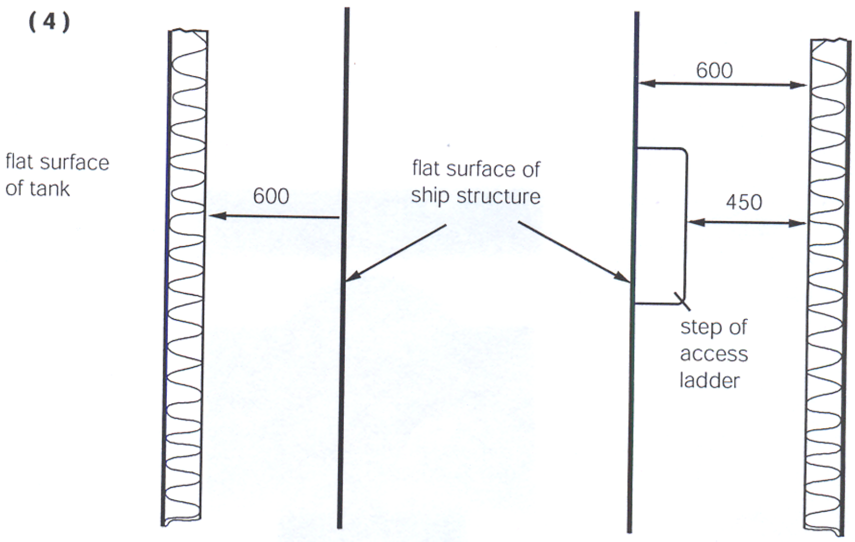

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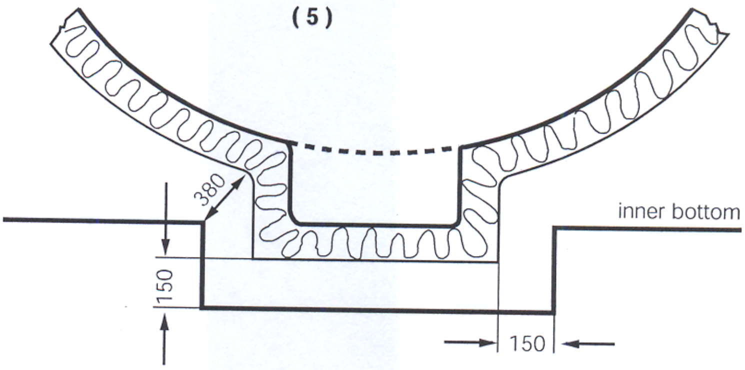

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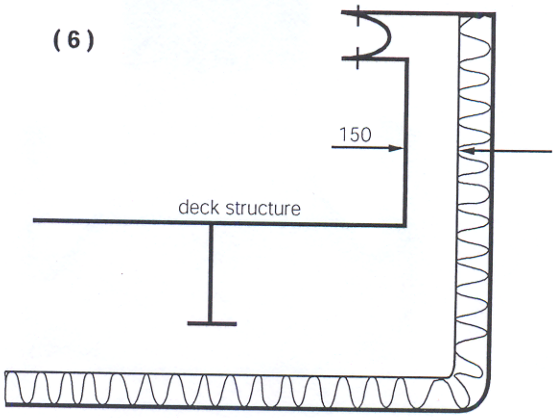


Fig.3.5.2(6)

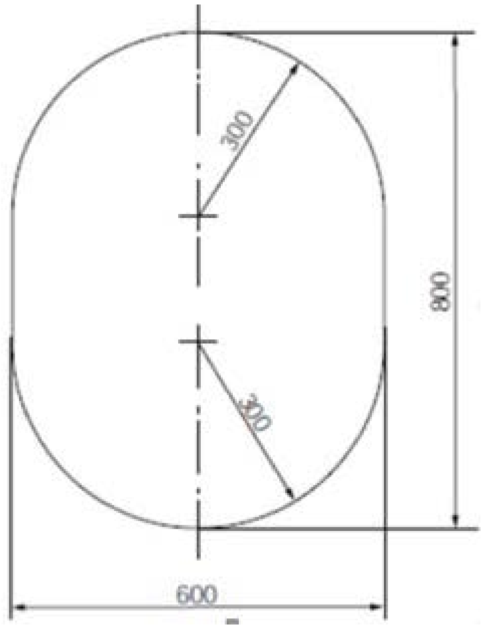


Fig.3.5.3.1

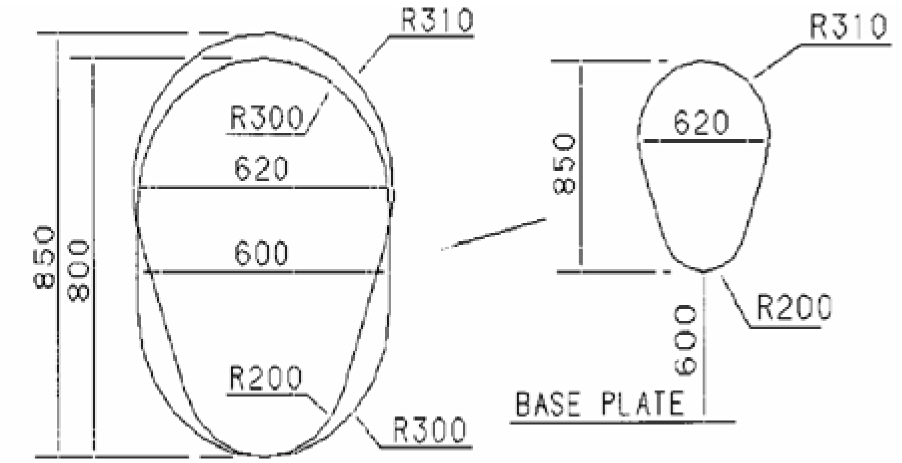


Fig.3.5.3.2

3.6 Air-locks

3.6.1 Access between hazardous area on the open weather deck and non-hazardous spaces is to be by means of an airlock. This is to consist of two self-closing, substantially gastight, steel doors without any holding back arrangements, capable of maintaining the overpressure, at least 1.5 m but no more than 2.5 m apart. The airlock space is to be artificially ventilated from a non-hazardous area and maintained at an overpressure to the hazardous area on the weather deck.

3.6.2 Where spaces are protected by pressurization, the ventilation is to be designed and installed in accordance with IEC 60092-502:1999.

3.6.3 An audible and visual alarm to give a warning on both sides of the air-lock is to be provided. The visible alarm is to indicate if one door is open. The audible alarm is to sound if doors on both sides of the air-lock are moved from the closed positions.

3.6.4 In ships carrying flammable products, electrical equipment that is located in spaces protected by air-locks and not of the certified safe type, are to be de-energized in case of loss of over-pressure in the space

3.6.5 Electrical equipment for manoeuvring, anchoring and mooring, as well as emergency fire pumps that are located in spaces protected by airlocks, are to be of a certified safe type.

3.6.6 The air-lock space is to be monitored for cargo vapour.(see 13.6.2)

3.6.7 Subject to the requirements of the International Convention on Load Lines in force, the door sill is not to be less than 300 [mm] in height.

3.7 Bilge, ballast and oil fuel arrangements

3.7.1 Where cargo is carried in a cargo containment system not requiring a secondary barrier, suitable drainage arrangements for the hold spaces that are not connected with the machinery space to be provided. Means of detecting such leakage are to be provided.

3.7.2 Where there is a secondary barrier, suitable drainage arrangements for dealing with any leakage into the hold or insulation spaces through adjacent ship structure are to be provided. The suction is not to be led to pumps inside the machinery space. Means of detecting such leakage are to be provided.

3.7.3 The hold or interbarrier space of Type A independent tanks are to be provided with a drainage system suitable for handling liquid cargo in the event of cargo tank leakage or rupture. Such arrangements are to provide for the return of any cargo leakage to the liquid cargo piping.

3.7.4 The arrangements referred to in 3.7.3 is to be provided with a removable spool piece.

3.7.5 Ballast spaces including wet duct keels used as ballast piping, fuel oil tanks and non-hazardous spaces, may be connected to pumps in the machinery spaces. Dry duct keels with ballast piping passing through, may be connected to pumps in the machinery spaces, provided the connections are led directly to the pumps and the discharge from the pumps are led directly overboard with no valves or manifolds in either line that could connect the line from the duct keel to the lines serving non-hazardous spaces . Pump vents are not to be open to machinery spaces.

IR 3.7.4 The requirements of “Pump vents are not to be open to machinery spaces” apply only to pumps in the machinery spaces serving dry duct keels through which ballast piping passes.

3.8 Bow or stern loading and unloading arrangements

3.8.1 Subject to the requirements of this Section and Sec 5, cargo piping may be arranged to permit bow or stern loading and unloading.

3.8.2 Bow or stern loading and unloading lines that are led past accommodation spaces, service spaces or control stations are not to be used for the transfer of products requiring a Type 1G ship. Bow or stern loading and unloading lines are not to be used for the transfer of toxic products as specified in 1.2.53, where the design pressure is above 2.5 [Mpa].

3.8.3 Portable arrangements are not permitted.

3.8.4.1 Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and control stations are not to face the cargo shore connection location of bow or stern loading and unloading arrangements. They are to be located on the outboard side of the superstructure or deckhouse at a distance of at least four per cent of the length of the ship but not less than 3 [m] from the end of the superstructure or deckhouse facing the cargo shore connection location of the bow or stern loading and unloading arrangements. This distance need not exceed 5 [m].

3.8.4.2 Windows and side scuttles facing the shore connection location and on the sides of the superstructure or deckhouse within the distance mentioned above are to be of the fixed (non-opening) type.

3.8.4.3 In addition, during the use of the bow or stern loading and unloading arrangements, all doors, ports and other openings on the corresponding superstructure or deckhouse side are to be kept closed.

3.8.4.4 Where, in the case of small ships, compliance with 3.2.4.1 to 3.2.4.4 and 3.8.4.1 to 3.8.4.3 is not possible, IRS may approve relaxations from the above requirements.

3.8.5 Deck openings and air inlets and outlets to spaces within distances of 10 [m] from the cargo shore connection location are to be kept closed during the use of bow or stern loading or unloading arrangements.

3.8.6 Fire-fighting arrangements for the bow or stern loading and unloading areas are to be in accordance with 11.3.1.3 and 11.4.7.

3.8.7 Means of communication between the cargo control station and shore connection location are to be provided and where applicable, certified for use in hazardous areas.

IR 3.9 Emergency towing arrangement (ETA)

IR 3.9.1 All gas carriers of deadweight 20,000 tonnes and above are to be provided with emergency towing arrangements at both forward and aft ends. Emergency towing arrangements are to be as per Pt.5, Ch.2, Sec.2.

IR 3.10 Hull construction

IR 3.10.1 The scantlings and arrangements of the hull structure would be specially considered in each case.

Section 4

Cargo Containment

4.0 Goal

To ensure the safe containment of cargo under all design and operating conditions having regard to the nature of the cargo carried. This will include measures to:

.1 provide strength to withstand defined loads;

.2 maintain the cargo in a liquid state;

.3 design for or protect the hull structure from low temperature exposure; and

.4 prevent the ingress of water or air into the cargo containment system.

4.1 Definitions

4.1.1 *A cold spot* is a part of the hull or thermal insulation surface where a localized temperature decrease occurs with respect to the allowable minimum temperature of the hull or of its adjacent hull structure, or to design capabilities of cargo pressure/temperature control systems required in Sec 7.

4.1.2 *Design vapour pressure* "P_0" is the maximum gauge pressure, at the top of the tank, to be used in the design of the tank.

4.1.3 *Design temperature* for selection of materials is the minimum temperature at which cargo may be loaded or transported in the cargo tanks.

4.1.4 *Independent tanks* are self-supporting tanks. They do not form part of the ship's hull and are not essential to the hull strength. There are three categories of independent tank, which are referred to in 4.21, 4.22 and 4.23.

4.1.5 *Membrane tanks* are non-self-supporting tanks that consist of a thin liquid and gastight layer (membrane) supported through insulation by the adjacent hull structure. Membrane tanks are covered in 4.24.

4.1.6 *Integral tanks* are tanks that form a structural part of the hull and are influenced in the same manner by the loads that stress the adjacent hull structure. Integral tanks are covered in 4.25.

4.1.7 *Semi-membrane tanks* are non-self-supporting tanks in the loaded condition and consist of a layer, parts of which are supported through insulation by the adjacent hull structure. Semi-membrane tanks are covered in 4.26.

4.1.8 In addition to the definitions in 1.2, the definitions given in this chapter shall apply throughout the Chapter

4.2 Application

Unless otherwise specified in part E, the requirements of parts A to D will apply to all types of tanks, including those covered in part F.

Part A
Cargo Containment

4.3 Functional Requirements

4.3.1 The design life of the cargo containment system is not to be less than the design life of the ship.

4.3.2 Cargo containment systems are to be designed for North Atlantic environmental conditions and relevant long-term sea state scatter diagrams for unrestricted navigation. Lesser environmental conditions, consistent with the expected usage, may be accepted by the IRS for cargo containment systems used exclusively for restricted navigation. Greater environmental conditions may be required for cargo containment systems operated in conditions more severe than the North Atlantic environment.

4.3.3 Cargo containment systems are to be designed with suitable safety margins:

.1 to withstand, in the intact condition, the environmental conditions anticipated for the cargo containment system's design life and the loading conditions appropriate for them, which include full homogeneous and partial load conditions, partial filling within defined limits and ballast voyage loads; and

.2 being appropriate for uncertainties in loads, structural modelling, fatigue, corrosion, thermal effects, material variability, ageing and construction tolerances.

4.3.4 The cargo containment system structural strength is to be assessed against failure modes, including but not limited to plastic deformation, buckling and fatigue. The specific design conditions which is to be considered for the design of each cargo containment system are given in 4.21 to 4.26. There are three main categories of design conditions:

.1 Ultimate design conditions – the cargo containment system structure and its structural components are to withstand loads liable to occur during its construction, testing and anticipated use in service, without loss of structural integrity. The design is to take into account proper combinations of the following loads:

.1 internal pressure;

.2 external pressure;

.3 dynamic loads due to the motion of the ship;

.4 thermal loads;

.5 sloshing loads;

.6 loads corresponding to ship deflections;

.7 tank and cargo weight with the corresponding reaction in way of supports;

.8 insulation weight;

.9 loads in way of towers and other attachments; and

.10 test loads.

.2 Fatigue design conditions – the cargo containment system structure and its structural components are not to fail under accumulated cyclic loading.

.3 The cargo containment system is to meet the following criteria:

.1 Collision – the cargo containment system is to be protectively located in accordance with 2.4.1 and withstand the collision loads specified in 4.15.1 without deformation of the supports, or the tank structure in way of the supports, likely to endanger the tank structure.

.2 Fire – the cargo containment systems is to sustain, without rupture, the rise in internal pressure specified in 8.4.1 under the fire scenarios envisaged therein.

.3 Flooded compartment causing buoyancy on tank – the anti-flotation arrangements are to sustain the upward force, specified in 4.15.2, and there shall be no endangering plastic deformation to the hull.

4.3.5 Measures are to be applied to ensure that scantlings required meet the structural strength provisions and be maintained throughout the design life. Measures may include, but are not limited to, material selection, coatings, corrosion additions, cathodic protection and inerting. Corrosion allowance need not be required in addition to the thickness resulting from the structural analysis. However, where there is no environmental control, such as inerting around the cargo tank, or where the cargo is of a corrosive nature, IRS may require a suitable corrosion allowance.

4.3.6 An inspection/survey plan for the cargo containment system is to be developed and approved by IRS. The inspection/survey plan is to identify areas that need inspection during surveys throughout the cargo containment system's life and, in particular, all necessary in-service survey and maintenance that was assumed when selecting cargo containment system design parameters. Cargo containment systems are to be designed, constructed and equipped to provide adequate means of access to areas that need inspection as specified in the inspection/survey plan. Cargo containment systems, including all associated internal equipment, shall be designed and built to ensure safety during operations, inspection and maintenance (see 3.5).

4.4 Cargo containment safety principles

4.4.1 The containment systems are to be provided with a full secondary liquid-tight barrier capable of safely containing all potential leakages through the primary barrier and, in conjunction with the thermal insulation system, of preventing lowering of the temperature of the ship structure to an unsafe level.

4.4.2 However, the size and configuration or arrangement of the secondary barrier may be reduced where an equivalent level of safety is demonstrated in accordance with the requirements of 4.4.3 to 4.4.5, as applicable.

4.4.3 Cargo containment systems for which the probability for structural failures to develop into a critical state has been determined to be extremely low, but where the possibility of leakages through the primary barrier cannot be excluded, shall be equipped with a partial secondary barrier and small leak protection system capable of safely handling and disposing of the leakages. The arrangements shall comply with the following requirements:

.1 failure developments that can be reliably detected before reaching a critical state (e.g. by gas detection or inspection) shall have a sufficiently long development time for remedial actions to be taken; and

.2 failure developments that cannot be safely detected before reaching a critical state are to have a predicted development time that is much longer than the expected lifetime of the tank.

4.4.4 No secondary barrier is required for cargo containment systems, e.g. type C independent tanks, where the probability for structural failures and leakages through the primary barrier is extremely low and can be neglected.

4.4.5 No secondary barrier is required where the cargo temperature at atmospheric pressure is at or above -10 [°C].

4.5 Secondary barriers in relation to tank types

Secondary barriers in relation to the tank types defined in 4.21 to 4.26 shall be provided in accordance with the following table.

Cargo temperature at atmospheric pressure	-10 [°C] and above	Below -10 [°C] down to -55 [°C]	Below -55 [°C]
Basic tank type	No secondary barrier required	Hull may act as secondary barrier	Separate secondary barrier where required
Integral		Tank type not normally allowed (1)	
Membrane		Complete secondary barrier	
Semi-membrane		Complete secondary barrier (2)	
Independent			
Type A		Complete secondary barrier	
Type B		Partial secondary barrier	
Type C		No secondary barrier required	

Notes:

1 A complete secondary barrier is normally to be required if cargoes with a temperature at atmospheric pressure below -10°C are permitted in accordance with 4.25.1.

2 In the case of semi-membrane tanks that comply in all respects with the requirements applicable to type B independent tanks, except for the manner of support, IRS may, after special consideration, accept a partial secondary barrier.

4.6 Design of secondary barriers

4.6.1 Where the cargo temperature at atmospheric pressure is not below -55 [°C], the hull structure may act as a secondary barrier based on the following:

.1 the hull material is to be suitable for the cargo temperature at atmospheric pressure as required by 4.19.1.4; and

.2 the design is to be such that this temperature will not result in unacceptable hull stresses.

4.6.2 The design of the secondary barrier is to be such that:

.1 it is capable of containing any envisaged leakage of liquid cargo for a period of 15 days, unless different criteria apply for particular voyages, taking into account the load spectrum referred to in 4.18.2.6;

.2 physical, mechanical, or operational events within the cargo tank that could cause failure of the primary barrier is not to impair the due function of the secondary barrier, or vice versa;

.3 failure of a support or an attachment to the hull structure will not lead to loss of liquid tightness of both the primary and secondary barriers;

.4 it is capable of being periodically checked for its effectiveness by means acceptable to IRS. This may be by means of a visual inspection or a pressure/vacuum test or other suitable means carried out according to a documented procedure agreed with IRS.

.5 the methods required in .4 above are to be approved by IRS and are to include, where applicable to the test procedure:

.1 details on the size of defect acceptable and the location within the secondary barrier, before its liquid-tight effectiveness is compromised;

.2 accuracy and range of values of the proposed method for detecting defects in .1 above;

.3 scaling factors to be used in determining the acceptance criteria, if full scale model testing is not undertaken; and

.4 effects of thermal and mechanical cyclic loading on the effectiveness of the proposed test; and

.6 the secondary barrier is to fulfill its functional requirements at a static angle of heel of 30°.

IR 4.6.2 For containment system with glued secondary barriers:

.1 At the time of construction, a tightness test is to be carried out in accordance with approved system designer's procedures and acceptance criteria before and after initial cool down. Low differential pressures tests are not considered as acceptable test.

.2 If the designer's threshold values are exceeded, an investigation is to be carried out and additional testing such as thermographic or acoustic emissions testing is to be carried out.

.3 The values recorded are to be used as reference for future assessment of secondary barrier tightness.

For containment systems with welded metallic secondary barriers, a tightness test after initial cool down is not required.

4.7 Partial secondary barriers and primary barrier small leak protection system

4.7.1 Partial secondary barriers as permitted in 4.4.3 are to be used with a small leak protection system and meet all the requirements in 4.6.2. The small leak protection system is to include means to detect a leak in the primary barrier, provision such as a spray shield to deflect any liquid cargo down into the partial secondary barrier, and means to dispose of the liquid, which may be by natural evaporation.

4.7.2 The capacity of the partial secondary barrier is to be determined, based on the cargo leakage corresponding to the extent of failure resulting from the load spectrum referred to in 4.18.2.6, after the initial detection of a primary leak. Due account may be taken of liquid evaporation, rate of leakage, pumping capacity and other relevant factors.

4.7.3 The required liquid leakage detection may be by means of liquid sensors, or by an effective use of pressure, temperature or gas detection systems, or any combination thereof.

4.8 Supporting arrangements

4.8.1 The cargo tanks are to be supported by the hull in a manner that prevents bodily movement of the tank under the static and dynamic loads defined in 4.12 to 4.15, where applicable, while allowing contraction and expansion of the tank under temperature variations and hull deflections without undue stressing of the tank and the hull.

4.8.2 Anti-flotation arrangements are to be provided for independent tanks and capable of withstanding the loads defined in 4.15.2 without plastic deformation likely to endanger the hull structure.

4.8.3 Supports and supporting arrangements are to withstand the loads defined in 4.13.9 and 4.15, but these loads need not be combined with each other or with wave-induced loads.

4.9 Associated structure and equipment

4.9.1 Cargo containment systems are to be designed for the loads imposed by associated structure and equipment. This includes pump towers, cargo domes, cargo pumps and piping, stripping pumps and piping, nitrogen piping, access hatches, ladders, piping penetrations, liquid level gauges, independent level alarm gauges, spray nozzles, and instrumentation systems (such as pressure, temperature and strain gauges).

4.10 Thermal insulation

4.10.1 Thermal insulation is to be provided, as required, to protect the hull from temperatures below those allowable (see 4.19.1) and limit the heat flux into the tank to the levels that can be maintained by the pressure and temperature control system applied in Sec 7.

4.10.2 In determining the insulation performance, due regard is to be given to the amount of the acceptable boil-off in association with the reliquefaction plant on board, main propulsion machinery or other temperature control system.

Part B
Design Loads

4.11 General

This section defines the design loads to be considered with regard to the requirements in 4.16, 4.17 and 4.18. This includes:

.1 load categories (permanent, functional, environmental and accidental) and the description of the loads;

.2 the extent to which these loads are to be considered depending on the type of tank, and is more fully detailed in the following paragraphs; and

.3 tanks, together with their supporting structure and other fixtures, that are to be designed taking into account relevant combinations of the loads described below.

4.12 Permanent loads

4.12.1 *Gravity loads*

The weight of tank, thermal insulation, loads caused by towers and other attachments shall be considered.

4.12.2 *Permanent external loads*

Gravity loads of structures and equipment acting externally on the tank shall be considered.

4.13 Functional loads

4.13.1 Loads arising from the operational use of the tank system are to be classified as functional loads. All functional loads that are essential for ensuring the integrity of the tank system, during all design conditions, are to be considered. As a minimum, the effects from the following criteria, as applicable, are to be considered when establishing functional loads:

.1 internal pressure;

.2 external pressure;

.3 thermally induced loads;

.4 vibration;

.5 interaction loads;

.6 loads associated with construction and installation;

.7 test loads;

.8 static heel loads; and

.9 weight of cargo.

4.13.2 ***Internal pressure***

.1 In all cases, including 4.13.2.2, P_o is not to be less than MARVS.

.2 For cargo tanks, where there is no temperature control and where the pressure of the cargo is dictated only by the ambient temperature, P_o is not to be less than the gauge vapour pressure of the cargo at a temperature of 45 [°C] except as follows:

.1 lower values of ambient temperature may be accepted by IRS for ships operating in restricted areas. Conversely, higher values of ambient temperature may be required; and

.2 for ships on voyages of restricted duration, P_o may be calculated based on the actual pressure rise during the voyage, and account may be taken of any thermal insulation of the tank.

.3 Subject to special consideration by the Administration/ IRS and to the limitations given in 4.21 to 4.26, for the various tank types, a vapour pressure P_h higher than P_o may be accepted for site specific conditions (harbour or other locations), where dynamic loads are reduced. Any relief valve setting resulting from this paragraph is to be recorded in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

.4 The internal pressure P_{eq} results from the vapour pressure P_o or P_h plus the maximum associated dynamic liquid pressure P_{gd}, , but not including the effects of liquid sloshing loads. Guidance formulae for associated dynamic liquid pressure P_{gd} are given in 4.28.1.

4.13.3 ***External pressure***

External design pressure loads are to be based on the difference between the minimum internal pressure and the maximum external pressure to which any portion of the tank may be simultaneously subjected.

4.13.4 ***Thermally induced loads***

4.13.4.1 Transient thermally induced loads during cooling down periods are to be considered for tanks intended for cargo temperatures below -55 [°C].

4.13.4.2 Stationary thermally induced loads are to be considered for cargo containment systems where the design supporting arrangements or attachments and operating temperature may give rise to significant thermal stresses (see 7.2).

4.13.5 ***Vibration***

The potentially damaging effects of vibration on the cargo containment system are to be considered.

4.13.6 ***Interaction loads***

The static component of loads resulting from interaction between cargo containment system and the hull structure, as well as loads from associated structure and equipment, are to be considered.

4.13.7 ***Loads associated with construction and installation***

Loads or conditions associated with construction and installation, e.g. lifting, are to be considered.

4.13.8 ***Test loads***

Account is to be taken of the loads corresponding to the testing of the cargo containment system referred to in 4.21 to 4.26.

4.13.9 ***Static heel loads***

Loads corresponding to the most unfavourable static heel angle within the range 0° to 30° are to be considered.

4.13.10 ***Other loads***

Any other loads not specifically addressed, which could have an effect on the cargo containment system, are to be taken into account.

4.14 Environmental loads

Environmental loads are defined as those loads on the cargo containment system that are caused by the surrounding environment and that are not otherwise classified as a permanent, functional or accidental load.

4.14.1 ***Loads due to ship motion***

4.14.1.1 The determination of dynamic loads is to be take into account the long-term distribution of ship motion in irregular seas, which the ship will experience during its operating life. Account may be taken of the reduction in dynamic loads due to necessary speed reduction and variation of heading.

4.14.1.2 The ship's motion is to include surge, sway, heave, roll, pitch and yaw. The accelerations acting on tanks are to be estimated at their centre of gravity and include the following components:

.1 vertical acceleration: motion accelerations of heave, pitch and, possibly, roll (normal to the ship base);

.2 transverse acceleration: motion accelerations of sway, yaw and roll and gravity component of roll; and

.3 longitudinal acceleration: motion accelerations of surge and pitch and gravity component of pitch.

4.14.1.3 Methods to predict accelerations due to ship motion are to be proposed and approved by IRS.

4.14.1.4 Guidance formulae for acceleration components are given in 4.28.2.

4.14.1.5 Ships for restricted service may be given special consideration.

4.14.2 ***Dynamic interaction loads***

Account is to be taken of the dynamic component of loads resulting from interaction between cargo containment systems and the hull structure, including loads from associated structures and equipment.

4.14.3 ***Sloshing loads***

4.14.3.1 The sloshing loads on a cargo containment system and internal components are to be evaluated based on allowable filling levels.

4.14.3.2 When significant sloshing-induced loads are expected to be present, special tests and calculations are to be required covering the full range of intended filling levels.

4.14.4 ***Snow and ice loads***

Snow and icing are to be considered, if relevant.

4.14.5 ***Loads due to navigation in ice***

Loads due to navigation in ice are to be considered for vessels intended for such service.

4.15 Accidental loads

Accidental loads are defined as loads that are imposed on a cargo containment system and its supporting arrangements under abnormal and unplanned conditions.

4.15.1 ***Collision loads***

The collision load is to be determined based on the cargo containment system under fully loaded condition with an inertial force corresponding to 0.5 g in the forward direction and 0.25 g in the aft direction, where "g" is gravitational acceleration.

4.15.2 ***Loads due to flooding on ship***

For independent tanks, loads caused by the buoyancy of an empty tank in a hold space flooded to the summer load draught are to be considered in the design of the anti-flotation chocks and the supporting hull structure.

Part C
Structural Integrity

4.16 General

4.16.1 The structural design is to ensure that tanks have an adequate capacity to sustain all relevant loads with an adequate margin of safety. This is to take into account the possibility of plastic deformation, buckling, fatigue and loss of liquid and gas tightness.

4.16.2 The structural integrity of cargo containment systems is to be demonstrated by compliance with 4.21 to 4.26, as appropriate, for the cargo containment system type.

4.16.3 The structural integrity of cargo containment system types that are of novel design and differ significantly from those covered by 4.21 to 4.26 is to be demonstrated by compliance with 4.27 to ensure that the overall level of safety provided in this section is maintained.

4.17 Structural analyses

4.17.1 ***Analysis***

4.17.1.1 The design analyses is to be based on accepted principles of statics, dynamics and strength of materials.

4.17.1.2 Simplified methods or simplified analyses may be used to calculate the load effects, provided that they are conservative. Model tests may be used in combination with, or instead of, theoretical calculations. In cases where theoretical methods are inadequate, model or full-scale tests may be required.

4.17.1.3 When determining responses to dynamic loads, the dynamic effect is to be taken into account where it may affect structural integrity.

4.17.2 ***Load scenarios***

4.17.2.1 For each location or part of the cargo containment system to be considered and for each possible mode of failure to be analysed, all relevant combinations of loads that may act simultaneously are to be considered.

4.17.2.2 The most unfavourable scenarios for all relevant phases during construction, handling, testing and in service, and conditions are to be considered.

4.17.3 When the static and dynamic stresses are calculated separately, and unless other methods of calculation are justified, the total stresses are to be calculated according to:

$$\sigma_x = \sigma_{x.st} \pm \sqrt{\sum(\sigma_{x.dyn})^2}$$
$$\sigma_y = \sigma_{y.st} \pm \sqrt{\sum(\sigma_{y.dyn})^2}$$
$$\sigma_z = \sigma_{z.st} \pm \sqrt{\sum(\sigma_{z.dyn})^2}$$
$$\tau_{xy} = \tau_{xy.st} \pm \sqrt{\sum(\tau_{xy.dyn})^2}$$
$$\tau_{xz} = \tau_{xz.st} \pm \sqrt{\sum(\tau_{xz.dyn})^2}$$
$$\tau_{yz} = \tau_{yz.st} \pm \sqrt{\sum(\tau_{yz.dyn})^2}$$

Where:

$\sigma_{x.st}, \sigma_{y.st}, \sigma_{z.st}, \tau_{xy.st}, \tau_{xz.st}, and\ \tau_{yz.st}$ are static stresses and

$\sigma_{x.dyn}, \sigma_{y.dyn}, \sigma_{z.dyn}, \tau_{xy.dyn}, \tau_{xz.dyn}\ and\ \tau_{yz.dyn}$ are dynamic stresses.

Each to be determined separately from acceleration components and hull strain components due to deflection and torsion.

4.18 Design conditions

All relevant failure modes are to be considered in the design for all relevant load scenarios and design conditions. The design conditions are given in the earlier part of this chapter, and the load scenarios are covered by 4.17.2.

4.18.1 ***Ultimate design condition***

Structural capacity may be determined by testing, or by analysis, taking into account both the elastic and plastic material properties, by simplified linear elastic analysis or by the provisions of this chapter.

4.18.1.1 Plastic deformation and buckling are to be considered.

4.18.1.2 Analysis is to be based on characteristic load values as follows:

Permanent loads :	Expected values
Functional loads :	Specified values
Environmental loads:	For wave loads: most probable largest load encountered during 10^8 wave encounters.

4.18.1.3 For the purpose of ultimate strength assessment, the following material parameters apply:

.1.1 R_e = specified minimum yield stress at room temperature (N/mm^2). If the stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies.

.1.2 R_m = specified minimum tensile strength at room temperature (N/mm^2).

For welded connections where under-matched welds, i.e. where the weld metal has lower tensile strength than the parent metal, are unavoidable, such as in some aluminium alloys, the respective R_e and R_m of the welds, after any applied heat treatment, is to be used. In such cases, the transverse weld tensile strength is not to be less than the actual yield strength of the parent metal. If this cannot be achieved, welded structures made from such materials is not to be incorporated in cargo containment systems.

.2 The above properties are to correspond to the minimum specified mechanical properties of the material, including the weld metal in the as-fabricated condition. Subject to special consideration by IRS, account may be taken of the enhanced yield stress and tensile strength at low temperature. The temperature on which the material properties are based is to be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required in 1.4.

4.18.1.4 The equivalent stress σ_c (von Mises, Huber) is to be determined by:

$$\sigma_c = \sqrt{\sigma_x^2 + \sigma_y^2 + \sigma_z^2 - \sigma_x\sigma_y - \sigma_x\sigma_z - \sigma_y\sigma_z + 3\left(\tau_{xy}^2 + \tau_{xz}^2 + \tau_{yz}^2\right)}$$

Where:

σ_x=total normal stress in x-direction
σ_y=total normal stress in y-direction
σ_z=total normal stress in z-direction
τ_{xy}=total shear stress in x-y plane
τ_{xz}=total shear stress in x-z plane
τ_{yz}=total shear stress in y-z plane

The above values to be calculated as described in 4.17.3

4.18.1.5 Allowable stresses for materials other than those covered by Sec 6 are subject to approval by the IRS in each case.

4.18.1.6 Stresses may be further limited by fatigue analysis, crack propagation analysis and buckling criteria.

4.18.2 ***Fatigue design condition***

4.18.2.1 The fatigue design condition is the design condition with respect to accumulated cyclic loading.

4.18.2.2 Where a fatigue analysis is required, the cumulative effect of the fatigue load shall comply with:

$$\sum \frac{n_i}{N_i} + \frac{n_{Loading}}{N_{Loading}} \le C_w$$

Where:

n_i=number of stress cycles at each stress level during the life of the tank

N_i=number of cycles to fracture for the respective stress level according to the Wohler (S-N) Curve.

$n_{Loading}$=number of loading and unloading cycles during the life of the tank, not to be less than 1000. Loading and unloading cycles include a complete pressure and thermal cycle;

$N_{Loading}$=number of cycles to fracture for the fatigue loads due to loading and unloading; and

C_w=maximum allowable cumulative fatigue damage ratio.

The fatigue damage is to be based on the design life of the tank but not less than 10^8 wave encounters.

4.18.2.3 Where required, the cargo containment system shall be subject to fatigue analysis, considering all fatigue loads and their appropriate combinations for the expected life of the cargo containment system. Consideration shall be given to various filling conditions.

4.18.2.4.1 Design S-N curves used in the analysis shall be applicable to the materials and weldments, construction details, fabrication procedures and applicable state of the stress envisioned.

4.18.2.4.2 The S-N curves shall be based on a 97.6% probability of survival corresponding to the mean-minus-two-standard-deviation curves of relevant experimental data up to final failure. Use of S-N curves derived in a different way requires adjustments to the acceptable C_w values specified in 4.18.2.7 to 4.18.2.9.

4.18.2.5 Analysis shall be based on characteristic load values as follows:

Permanent loads :	Expected values
Functional loads :	Specified values or specified history
Environmental loads:	Expected load history, but not less than 10^8 cycle.

If simplified dynamic loading spectra are used for the estimation of the fatigue life, they shall be specially considered by the Administration/ IRS.

4.18.2.6.1 Where the size of the secondary barrier is reduced, as is provided for in 4.4.3, fracture mechanics analyses of fatigue crack growth shall be carried out to determine:

.1 crack propagation paths in the structure;

.2 crack growth rate;

.3 the time required for a crack to propagate to cause a leakage from the tank;

.4 the size and shape of through thickness cracks; and

.5 the time required for detectable cracks to reach a critical state.

The fracture mechanics are, in general, based on crack growth data taken as a mean value plus two standard deviations of the test data.

4.18.2.6.2 In analysing crack propagation, the largest initial crack not detectable by the inspection method applied is to be assumed, taking into account the allowable non-destructive testing and visual inspection criterion, as applicable.

4.18.2.6.3 Crack propagation analysis under the condition specified in 4.18.2.7: the simplified load distribution and sequence over a period of 15 days may be used. Such distributions may be obtained as indicated in Fig.4.4. Load distribution and sequence for longer periods, such as in 4.18.2.8 and 4.18.2.9 are to be approved by IRS.

4.18.2.6.4 The arrangements are to comply with 4.18.2.7 to 4.18.2.9, as applicable.

4.18.2.7 For failures that can be reliably detected by means of leakage detection:

C_w is to be less than or equal to 0.5.

Predicted remaining failure development time, from the point of detection of leakage till reaching a critical state, is not to be less than 15 days, unless different requirements apply for ships engaged in particular voyages.

4.18.2.8 For failures that cannot be detected by leakage but that can be reliably detected at the time of in-service inspections:

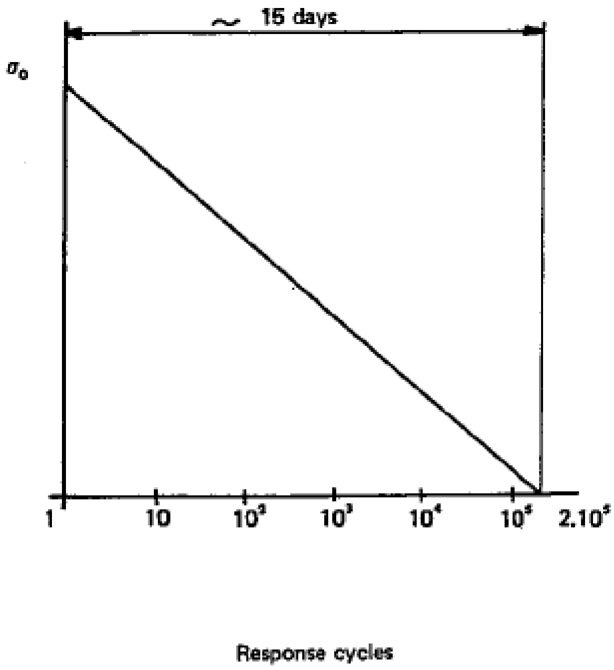
Cw is to be less than or equal to 0.5.

Predicted remaining failure development time, from the largest crack not detectable by in-service inspection methods until reaching a critical state, is not to be less than three times the inspection interval.

4.18.2.9 In particular locations of the tank, where effective defect or crack development detection cannot be assured, the following, more stringent, fatigue acceptance criteria is to be applied as a minimum:

Cw is to be less than or equal to 0.1.

Predicted failure development time, from the assumed initial defect until reaching a critical state, is not to be less than three times the lifetime of the tank.



σ_o = most probable maximum stress over the life of the ship

Response cycle scale is logarithmic; the value of 2.10^5 is given as an example of estimate.

Fig.4.4 : Simplified load distribution

4.18.3 ***Accident design condition***

4.18.3.1 The accident design condition is a design condition for accidental loads with extremely low probability of occurrence.

4.18.3.2 Analysis is to be based on the characteristic values as follows:

Permanent loads :	Expected values
Functional loads :	Specified values
Environmental loads:	Specified values
Accidental loads	Specified values or expected values

4.18.3.3 Loads mentioned in 4.13.9 and 4.15 need not be combined with each other or with wave-induced loads.

Part D
Materials and construction

4.19 Materials

4.19.0 Goal

To ensure that the cargo containment system, primary and secondary barriers, the thermal insulation, adjacent ship structure and other materials in the cargo containment system are constructed from materials of suitable properties for the conditions they will experience, both in normal service and in the event of failure of the primary barrier, where applicable.

4.19.1 ***Materials forming ship structure***

4.19.1.1 To determine the grade of plate and sections used in the hull structure, a temperature calculation is to be performed for all tank types when the cargo temperature is below -10°C. The following assumptions are to be made in this calculation:

.1 the primary barrier of all tanks is to be assumed to be at the cargo temperature;

.2 in addition to .1, where a complete or partial secondary barrier is required, it is to be assumed to be at the cargo temperature at atmospheric pressure for any one tank only;

.3 for worldwide service, ambient temperatures is to be taken as 5°C for air and 0ºC for seawater. Higher values may be accepted for ships operating in restricted areas and, conversely, lower values may be fixed by the Administration for ships trading to areas where lower temperatures are expected during the winter months;

.4 still air and seawater conditions are to be assumed, i.e. no adjustment for forced convection;

.5 degradation of the thermal insulation properties over the life of the ship due to factors such as thermal and mechanical ageing, compaction, ship motions and tank vibrations, as defined in 4.19.3.6 and 4.19.3.7, is to be assumed;

.6 the cooling effect of the rising boil-off vapour from the leaked cargo is to be taken into account, where applicable;

.7 credit for hull heating may be taken in accordance with 4.19.1.5, provided the heating arrangements are in compliance with 4.19.1.6;

.8 no credit is to be given for any means of heating, except as described in 4.19.1.5; and

.9 for members connecting inner and outer hulls, the mean temperature may be taken for determining the steel grade.

The ambient temperatures used in the design, described in this paragraph, are to be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required in 1.4.4.

4.19.1.2 The shell and deck plating of the ship and all stiffeners attached thereto are to be in accordance with recognized standards. If the calculated temperature of the material in the design condition is below -5 [°C] due to the influence of the cargo temperature, the material is to be in accordance with table 6.5.

4.19.1.3 The materials of all other hull structures for which the calculated temperature in the design condition is below 0 [°C], due to the influence of cargo temperature and that do not form the secondary barrier, are also to be in accordance with table 6.5. This includes hull structure supporting the cargo tanks, inner bottom plating, longitudinal bulkhead plating, transverse bulkhead plating, floors, webs, stringers and all attached stiffening members.

4.19.1.4 The hull material forming the secondary barrier is to be in accordance with table 6.2. Where the secondary barrier is formed by the deck or side shell plating, the material grade required by table 6.2 is to be carried into the adjacent deck or side shell plating, where applicable, to a suitable extent.

4.19.1.5 Means of heating structural materials may be used to ensure that the material temperature does not fall below the minimum allowed for the grade of material specified in table 6.5. In the calculations required in 4.19.1.1, credit for such heating may be taken in accordance with the following:

.1 for any transverse hull structure;

.2 for longitudinal hull structure referred to in 4.19.1.2 and 4.19.1.3 where colder ambient temperatures are specified, provided the material remains suitable for the ambient temperature conditions of +5°C for air and 0°C for seawater with no credit taken in the calculations for heating; and

.3 as an alternative to .2, for longitudinal bulkhead between cargo tanks, credit may be taken for heating, provided the material remain suitable for a minimum design temperature of -30 [°C], or a temperature 30 [°C] lower than that determined by 4.19.1.1 with the heating considered, whichever is less. In this case, the ship's longitudinal strength shall comply with SOLAS regulation II-1/3-1 for both when those bulkhead(s) are considered effective and not.

4.19.1.6 The means of heating referred to in 4.19.1.5 is to comply with the following requirements:

.1 the heating system is to be arranged so that, in the event of failure in any part of the system, standby heating can be maintained equal to not less than 100% of the theoretical heat requirement;

.2 the heating system is to be considered as an essential auxiliary. All electrical components of at least one of the systems provided in accordance with 4.19.1.5.1 is to be supplied from the emergency source of electrical power; and

.3 the design and construction of the heating system is to be included in the approval of the containment system by the IRS.

4.19.2 Materials of primary and secondary barriers

4.19.2.1 Metallic materials used in the construction of primary and secondary barriers not forming the hull, are to be suitable for the design loads that they may be subjected to, and be in accordance with, table 6.1, 6.2 or 6.3.

4.19.2.2 Materials, either non-metallic or metallic but not covered by tables 6.1, 6.2 and 6.3, used in the primary and secondary barriers may be approved by the IRS, considering the design loads that they may be subjected to, their properties and their intended use.

4.19.2.3 Where non-metallic materials, including composites, are used for, or incorporated in the primary or secondary barriers, they are to be tested for the following properties, as applicable, to ensure that they are adequate for the intended service:

.1 compatibility with the cargoes;

.2 ageing;

.3 mechanical properties;

.4 thermal expansion and contraction;

.5 abrasion;

.6 cohesion;

.7 resistance to vibrations;

.8 resistance to fire and flame spread; and

.9 resistance to fatigue failure and crack propagation.

4.19.2.4 The above properties, where applicable, are to be tested for the range between the expected maximum temperature in service and +5 [°C] below the minimum design temperature, but not lower than -196 [°C].

4.19.2.5.1 Where non-metallic materials, including composites, are used for the primary and secondary barriers, the joining processes are also to be tested as described above.

4.19.2.5.2 Guidance on the use of non-metallic materials in the construction of primary and secondary barriers is provided in appendix 4 of IGC Code.

4.19.2.6 Consideration may be given to the use of materials in the primary and secondary barrier, which are not resistant to fire and flame spread, provided they are protected by a suitable system such as a permanent inert gas environment, or are provided with a fire-retardant barrier.

4.19.3 Thermal insulation and other materials used in cargo containment systems

4.19.3.1 Load-bearing thermal insulation and other materials used in cargo containment systems are to be suitable for the design loads.

4.19.3.2 Thermal insulation and other materials used in cargo containment systems are to have the following properties, as applicable, to ensure that they are adequate for the intended service:

.1 compatibility with the cargoes;

.2 solubility in the cargo;

.3 absorption of the cargo;

.4 shrinkage;

.5 ageing;

.6 closed cell content;

.7 density;

.8 mechanical properties, to the extent that they are subjected to cargo and other loading effects, thermal expansion and contraction;

.9 abrasion;

.10 cohesion;

.11 thermal conductivity;

.12 resistance to vibrations;

.13 resistance to fire and flame spread; and

.14 resistance to fatigue failure and crack propagation.

4.19.3.3 The above properties, where applicable, are to be tested for the range between the expected maximum temperature in service and 5 [°C] below the minimum design temperature, but not lower than -196 [°C].

4.19.3.4 Due to location or environmental conditions, thermal insulation materials are to have suitable properties of resistance to fire and flame spread and are to be adequately protected against penetration of water vapour and mechanical damage. Where the thermal insulation is located on or above the exposed deck, and in way of tank cover penetrations, it is to have suitable fire resistance properties in accordance with recognized standards or be covered with a material having low flame-spread characteristics and forming an efficient approved vapour seal.

4.19.3.5 Thermal insulation that does not meet recognized standards for fire resistance may be used in hold spaces that are not kept permanently inerted, provided its surfaces are covered with material with low flame-spread characteristics and that forms an efficient approved vapour seal.

4.19.3.6 Testing for thermal conductivity of thermal insulation is to be carried out on suitably aged samples.

4.19.3.7 Where powder or granulated thermal insulation is used, measures are to be taken to reduce compaction in service and to maintain the required thermal conductivity and also prevent any undue increase of pressure on the cargo containment system.

4.20 Construction processes

4.20.0 Goal

To define suitable construction processes and test procedures in order to ensure, as far as reasonably practical, that the cargo containment system will perform satisfactorily in service in accordance with the assumptions made at the design stage.

4.20.1 Weld joint design

4.20.1.1 All welded joints of the shells of independent tanks are to be of the in-plane butt weld full penetration type. For dome-to-shell connections only, tee welds of the full penetration type may be used depending on the results of the tests carried out at the approval of the welding procedure. Except for small penetrations on domes, nozzle welds are also to be designed with full penetration.

4.20.1.2 Welding joint details for type C independent tanks, and for the liquid-tight primary barriers of type B independent tanks primarily constructed of curved surfaces, are to be as follows:

> .1 all longitudinal and circumferential joints are to be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds are to be obtained by double welding or by the use of backing rings. If used, backing rings are to be removed except from very small process pressure vessels. Other edge preparations may be permitted, depending on the results of the tests carried out at the approval of the welding procedure; and
>
> .2 the bevel preparation of the joints between the tank body and domes and between domes and relevant fittings are to be designed according to a standard acceptable to IRS. All welds connecting nozzles, domes or other penetrations of the vessel and all welds connecting flanges to the vessel or nozzles are to be full penetration welds.

4.20.1.3 Where applicable, all the construction processes and testing, except that specified in 4.20.3, are to be done in accordance with the applicable provisions of Sec 6.

4.20.2 Design for gluing and other joining processes

The design of the joint to be glued (or joined by some other process except welding) is to take account of the strength characteristics of the joining process.

4.20.3 Testing

4.20.3.1 All cargo tanks and process pressure vessels are to be subjected to hydrostatic or hydropneumatic pressure testing in accordance with 4.21 to 4.26, as applicable for the tank type.

4.20.3.2 All tanks are to be subject to a tightness test which may be performed in combination with the pressure test referred to in 4.20.3.1.

4.20.3.3 Requirements with respect to inspection of secondary barriers are to be decided by IRS in each case, taking into account the accessibility of the barrier (see 4.6.2).

4.20.3.4 The Administration/ IRS may require that for ships fitted with novel type B independent tanks, or tanks designed according to 4.27 at least one prototype tank and its supporting structures are to be instrumented with strain gauges or other suitable equipment to confirm stress levels. Similar instrumentation may be required for type C independent tanks, depending on their configuration and on the arrangement of their supports and attachments.

4.20.3.5 The overall performance of the cargo containment system is to be verified for compliance with the design parameters during the first full loading and discharging of the cargo, in accordance with the survey procedure and requirements in 1.4 and the requirements of IRS. Records of the performance of the components and equipment essential to verify the design parameters, are to be maintained and be available to the Administration/ IRS.

4.20.3.6 Heating arrangements, if fitted in accordance with 4.19.1.5 and 4.19.1.6, are to be tested for required heat output and heat distribution.

4.20.3.7 The cargo containment system is to be inspected for cold spots during, or immediately following, the first loaded voyage. Inspection of the integrity of thermal insulation surfaces that cannot be visually checked is to be carried out in accordance with recognized standards.

IR 4.20.4 Examination before and after the first loaded voyage for LNG Carriers.

IR 4.20.4.1 Following requirements applies to all vessels carrying liquefied natural gases (LNG) in bulk which have satisfactorily completed gas trials.

IR 4.20.4.2 the following initial certificates would be "conditionally" issued at delivery subject to satisfactory completion of the first cargo loading and unloading survey requirements below in the presence of a Surveyor:

i) Certificate of class

ii) Short Term Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

The conditions would be stated on the Certificate of Class or issued as a Condition of Class / Outstanding Recommendation in the vessel's Record.

IR 4.20.4.3 Survey requirements for first loading (considered to be full loading)

i) Priority will be given to latter stages of loading (approximately last 6 hours).

ii) Review of cargo logs and alarm reports

iii) Witness of satisfactory operation of the following:

a. Gas detection system.

b. Cargo control and monitoring systems such as level gauging equipment, temperature sensors, pressure gauges, cargo pumps and compressor, proper control of cargo heat exchangers, if operating, etc.

c. Nitrogen generating plant or inert gas generator, if operating.

d. Nitrogen pressure control system for insulation, interbarrier and annular spaces, as applicable.

e. Cofferdam heating system, if in operation.

f. Reliquefaction plant, if fitted.

g. Equipment fitted for the burning of cargo vapours such as boilers, engines, gas combustion units, etc., if operating.

iv) Examination of on-deck cargo piping systems including expansion and supporting arrangements.

v) Witness of topping off process for cargo tanks including high level alarms activated during normal loading.

vi) The master will be advised to carry out cold spot examination of the hull and external insulation during transit voyage to unloading port.

IR 4.20.4.4 Survey requirements for first unloading:

i) Priority will be given to the commencement of unloading (approximately first 4 – 6 hours).

ii) Witness of emergency shutdown system testing prior to commencement of unloading.

iii) Review of cargo logs and alarm reports.

iv) Witness of satisfactory operation of the following:

a. Gas detection system.

b. Cargo control and monitoring systems such as level gauging equipment, temperature sensors, pressure gauges, cargo pumps and compressors, proper control of cargo heat exchangers, if operating, etc.

c. Nitrogen generating plant or inert gas generators, if operating.

d. Nitrogen pressure control system for insulation, interbarrier and annular spaces, as applicable.

e. Cofferdam heating system, if in operation.

f. Reliquefaction plant and review of records from previous voyage.

g. Equipment fitted for the burning of cargo vapors such as boilers, engines, gas combustion units, etc., if operating.

v) On membrane vessels, verification that the readings of the cofferdam and inner hull temperature sensors are not below the allowable temperature for the selected grade of steel. Review of previous readings to be carried out.

vi) Examination of on-deck cargo piping systems including expansion and supporting arrangements.

vii) Written statement would be obtained from the Master that the cold spot examination was carried out during the transit voyage and found satisfactory. Where possible, the Surveyor would examine selected spaces.

Part E
Tank Types

4.21 Type A independent tanks

4.21.1 Design basis

4.21.1.1 Type A independent tanks are tanks primarily designed using classical ship-structural analysis procedures in accordance with recognized standards. Where such tanks are primarily constructed of plane surfaces, the design vapour pressure P_o is to be less than 0.07 [MPa].

4.21.1.2 If the cargo temperature at atmospheric pressure is below -10 [°C], a complete secondary barrier is to be provided as required in 4.5. The secondary barrier is to be designed in accordance with 4.6.

4.21.2 Structural analysis

4.21.2.1 A structural analysis is to be performed taking into account the internal pressure as indicated in 4.13.2, and the interaction loads with the supporting and keying system as well as a reasonable part of the ship's hull.

4.21.2.2 For parts, such as supporting structures, not otherwise covered by the requirements of the chapter, stresses are to be determined by direct calculations, taking into account the loads referred to in 4.12 to 4.15 as far as applicable, and the ship deflection in way of supporting structures.

4.21.2.3 The tanks with supports are to be designed for the accidental loads specified in 4.15. These loads need not be combined with each other or with environmental loads.

4.21.3 Ultimate design condition

4.21.3.1 For tanks primarily constructed of plane surfaces, the nominal membrane stresses for primary and secondary members (stiffeners, web frames, stringers, girders), when calculated by classical analysis procedures, are not to exceed the lower of R_m /2.66 or R_e /1.33 for nickel steels, carbon-manganese steels, austenitic steels and aluminium alloys, where R_m and R_e are defined in 4.18.1.3. However, if detailed calculations are carried out for the primary members, the equivalent stress $\sigma_{c,}$ as defined in 4.18.1.4, may be increased over that indicated above to a stress acceptable to IRS. Calculations are to take into account the effects of bending, shear, axial and torsional deformation as well as the hull/cargo tank interaction forces due to the deflection of the double bottom and cargo tank bottoms.

4.21.3.2 Tank boundary scantlings are to meet at least the requirements of IRS for deep tanks taking into account the internal pressure as indicated in 4.13.2 and any corrosion allowance required by 4.3.5.

4.21.3.3 The cargo tank structure is to be reviewed against potential buckling.

4.21.4 Accident design condition

4.21.4.1 The tanks and the tank supports are to be designed for the accidental loads and design conditions specified in 4.3.4.3 and 4.15, as relevant.

4.21.4.2 When subjected to the accidental loads specified in 4.15, the stress is to comply with the acceptance criteria specified in 4.21.3, modified as appropriate, taking into account their lower probability of occurrence.

4.21.5 Testing

All type A independent tanks are to be subjected to a hydrostatic or hydropneumatic test. This test is to be performed such that the stresses approximate, as far as practicable, the design stresses, and that the pressure at the top of the tank corresponds at least to the MARVS. When a hydropneumatic test is performed, the conditions are to simulate, as far as practicable, the design loading of the tank and of its support structure, including dynamic components, while avoiding stress levels that could cause permanent deformation.

4.22 Type B independent tanks

4.22.1 ***Design basis***

4.22.1.1 Type B independent tanks are tanks designed using model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics. Where such tanks are primarily constructed of plane surfaces (prismatic tanks), the design vapour pressure P_o is to be less than 0.07 [MPa].

4.22.1.2 If the cargo temperature at atmospheric pressure is below -10°C, a partial secondary barrier with a small leak protection system is to be provided as required in 4.5. The small leak protection system shall be designed according to 4.7.

4.22.2 *Structural analysis*

4.22.2.1 The effects of all dynamic and static loads are to be used to determine the suitability of the structure with respect to:

.1 plastic deformation;

.2 buckling;

.3 fatigue failure; and

.4 crack propagation.

Finite element analysis or similar methods and fracture mechanics analysis, or an equivalent approach, are to be carried out.

4.22.2.2 A three-dimensional analysis shall be carried out to evaluate the stress levels, including interaction with the ship's hull. The model for this analysis is to include the cargo tank with its supporting and keying system, as well as a reasonable part of the hull.

4.22.2.3 A complete analysis of the particular ship accelerations and motions in irregular waves, and of the response of the ship and its cargo tanks to these forces and motions are to be performed, unless the data is available from similar ships.

4.22.3 *Ultimate design condition*

4.22.3.1 Plastic deformation

4.22.3.1.1 For type B independent tanks, primarily constructed of bodies of revolution, the allowable stresses are not to exceed:

$$\sigma_m \le f$$
$$\sigma_L \le 1.5f$$
$$\sigma_b \le 1.5F$$
$$\sigma_L + \sigma_b \le 1.5F$$
$$\sigma_m + \sigma_b \le 1.5F$$
$$\sigma_m + \sigma_b + \sigma_g \le 3F$$
$$\sigma_L + \sigma_b + \sigma_g \le 3F$$

Where:

σ_m = equivalent primary general membrane stress;

σ_L = equivalent primary local membrane stress;

σ_b = equivalent primary bending stress;

σ_g = equivalent secondary stress;

f = the lesser of (R_m/A) or (R_e/B);

F = the lesser of (R_m/C) or (R_e/D)

with R_m and R_e as defined in 4.18.1.3. With regard to the stresses σ_m, σ_L, σ_b and σ_g, the definition of stress categories in 4.28.3 are referred. The values A and B are to be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk and shall have at least the following minimum values:

	Nickel steels and carbon manganese steels	Austenitic steels	Aluminium alloys
A	3	3.5	4
B	2	1.6	1.5
C	3	3	3
D	1.5	1.5	1.5

The above figures may be altered, taking into account the design condition considered in acceptance with the Administration/ IRS.

4.22.3.1.2 For type B independent tanks, primarily constructed of plane surfaces, the allowable membrane equivalent stresses applied for finite element analysis are not to exceed:

.1 for nickel steels and carbon-manganese steels, the lesser of R_m /2 or R_e /1.2;

.2 for austenitic steels, the lesser of R_m /2.5 or R_e /1.2; and

.3 for aluminium alloys, the lesser of R_m /2.5 or R_e /1.2.

The above figures may be amended, taking into account the locality of the stress, stress analysis methods and design condition considered in acceptance with the Administration/ IRS.

4.22.3.1.3 The thickness of the skin plate and the size of the stiffener is not to be less than those required for type A independent tanks.

4.22.3.2 Buckling

Buckling strength analyses of cargo tanks subject to external pressure and other loads causing compressive stresses are to be carried out in accordance with recognized standards. The method is to adequately account for the difference in theoretical and actual buckling stress as a result of plate edge misalignment, lack of straightness or flatness, ovality and deviation from true circular form over a specified arc or chord length, as applicable.

4.22.4 Fatigue design condition

4.22.4.1 Fatigue and crack propagation assessment is to be performed in accordance with 4.18.2. The acceptance criteria is to comply with 4.18.2.7, 4.18.2.8 or 4.18.2.9, depending on the detectability of the defect.

4.22.4.2 Fatigue analysis is to consider construction tolerances.

4.22.4.3 Where deemed necessary by the IRS, model tests may be required to determine stress concentration factors and fatigue life of structural elements.

4.22.5 Accident design condition

4.22.5.1 The tanks and the tank supports are to be designed for the accidental loads and design conditions specified in 4.3.4.3 and 4.15, as applicable.

4.22.5.2 When subjected to the accidental loads specified in 4.15, the stress is to comply with the acceptance criteria specified in 4.22.3, modified as appropriate, taking into account their lower probability of occurrence.

4.22.6 Testing

Type B independent tanks are to be subjected to a hydrostatic or hydropneumatic test as follows:

.1 the test is to be performed as required in 4.21.5 for type A independent tanks; and

.2 in addition, the maximum primary membrane stress or maximum bending stress in primary members under test conditions are not to exceed 90% of the yield strength of the material (as fabricated) at the test temperature. To ensure that this condition is satisfied, when calculations indicate that this stress exceeds 75% of the yield strength, the prototype test shall be monitored by the use of strain gauges or other suitable equipment.

4.22.7 Marking

Any marking of the pressure vessel is to be achieved by a method that does not cause unacceptable local stress raisers.

4.23 Type C independent tanks

4.23.1 Design basis

4.23.1.1 The design basis for type C independent tanks is based on pressure vessel criteria modified to include fracture mechanics and crack propagation criteria. The minimum design pressure defined in 4.23.1.2 is intended to ensure that the dynamic stress is sufficiently low, so that an initial surface flaw will not propagate more than half the thickness of the shell during the lifetime of the tank.

4.23.1.2 The design vapour pressure is not to be less than:

$$P_o = 0.2 + AC(\rho_r)^{1.5} \quad [MPa]$$

Where:

$$A = 0.00185\left(\frac{\sigma_m}{\Delta\sigma_A}\right)^2$$

With:

σ_m=design primary membrane stress

$\Delta\sigma_A$=allowable dynamic membrane stress (double amplitude at probability level Q=10^{-8}) and equal to :

- 55 [N/mm^2] for ferritic-perlitic , martensitic and austenitic steel;
- 25 [N/mm^2] for aluminium alloy (5083-O)

C = a characteristic tank dimension to be taken as the greatest of the following:

$h, 0.75b \text{ or } 0.45l$

with:

h = height of tank (dimension of ship's vertical direction) [m]

b = width of tank (dimension of ship's transverse direction) [m]

l = length of tank (dimension of ship's longitudinal direction) [m]

ρ_r=the relative density of the cargo (ρ_r=1 for fresh water) at the design temperature.

When a specified design life of the tank is longer than 10^8 wave encounters, $\Delta\sigma_A$ is to be modified to give equivalent crack propagation corresponding to the design life.

4.23.1.3 The Administration/ IRS may allocate a tank complying with the criteria of type C tank minimum design pressure as in 4.23.1.2, to a type A or type B, dependent on the configuration of the tank and the arrangement of its supports and attachments.

4.23.2 Shell thickness

4.23.2.1 The shell thickness is to be as follows:

.1 For pressure vessels, the thickness calculated according to 4.23.2.4 is to be considered as a minimum thickness after forming, without any negative tolerance.

.2 For pressure vessels, the minimum thickness of shell and heads including corrosion allowance, after forming, is not to be less than 5 [mm] for carbon-manganese steels and nickel steels, 3 [mm] for austenitic steels or 7 [mm] for aluminium alloys.

.3 The welded joint efficiency factor to be used in the calculation according to 4.23.2.4 is to be 0.95 when the inspection and the non-destructive testing referred to in 6.5.6.5 are carried out. This figure may be increased up to 1 when account is taken of other considerations, such as the material used, type of joints, welding procedure and type of loading. For process pressure vessels, IRS may accept partial non-destructive examinations, but not less than those of 6.5.6.5, depending on such factors as the material used, the design temperature, the nil-ductility transition temperature of the material, as fabricated, and the type of joint and welding procedure, but in this case an efficiency factor of not more than 0.85 is to be adopted. For special materials, the above-mentioned factors are to be reduced, depending on the specified mechanical properties of the welded joint.

4.23.2.2 The design liquid pressure defined in 4.13.2 is to be taken into account in the internal pressure calculations.

4.23.2.3 The design external pressure P_e, used for verifying the buckling of the pressure vessels, is not to be less than that given by:

$$P_e = P_1 + P_2 + P_3 + P_4 \quad [MPa]$$

Where:

P_1 = setting value of vacuum relief valves. For vessels not fitted with vacuum relief valves, P_1 is to be specially considered, but, in general, is not to be taken as less than 0.025 [MPa];

P_2 = the set pressure of the pressure relief valves (PRVs) for completely closed spaces containing pressure vessels or parts of pressure vessels; elsewhere P_2=0;

P_3 = compressive actions in or on the shell due to the weight and contraction of thermal insulation, weight of shell including corrosion allowance and other miscellaneous external pressure loads to which the pressure vessel may be subjected. These include, but are not limited to, weight of domes, weight of towers and piping, effect of product in the partially filled condition, accelerations and hull deflection. In addition, the local effect of external or internal pressures or both shall be taken into account; and

P_4 = external pressure due to head of water for pressure vessels or part of pressure vessels on exposed decks; elsewhere P_4 = 0.

4.23.2.4 Scantlings based on internal pressure are to be calculated as follows: the thickness and form of pressure-containing parts of pressure vessels, under internal pressure, as defined in 4.13.2, including flanges, are to be determined. These calculations in all cases are to be based on accepted pressure vessel design theory. Openings in pressure-containing parts of pressure vessels are to be reinforced in accordance with recognized standards.

4.23.2.5 Stress analysis in respect of static and dynamic loads are to be performed as follows:

.1 Pressure vessel scantlings are to be determined in accordance with 4.23.2.1 to 4.23.2.4 and 4.23.3.

.2 Calculations of the loads and stresses in way of the supports and the shell attachment of the support are to be made. Loads referred to in 4.12 to 4.15 are to be used, as applicable. Stresses in way of the supporting structures are to be to a recognized standard acceptable to IRS. In special cases, a fatigue analysis may be required by IRS.

.3 If required by IRS, secondary stresses and thermal stresses are to be specially considered.

4.23.3 *Ultimate design condition*

4.23.3.1 Plastic deformation

4.23.3.1.1 For type C independent tanks, the allowable stresses are not to exceed:

$$\sigma_m \le f$$
$$\sigma_L \le 1.5f$$
$$\sigma_b \le 1.5f$$
$$\sigma_L + \sigma_b \le 1.5f$$
$$\sigma_m + \sigma_b \le 1.5f$$
$$\sigma_m + \sigma_b + \sigma_g \le 3f$$
$$\sigma_L + \sigma_b + \sigma_g \le 3f$$

Where:

σ_m = equivalent primary general membrane stress;

σ_L = equivalent primary local membrane stress;

σ_b = equivalent primary bending stress;

σ_g = equivalent secondary stress;

f = the lesser of (R_m/A) or (R_e/B);

with R_m and R_e as defined in 4.18.1.3. With regard to the stresses σ_m, σ_L, σ_b and σ_g, the definition of stress categories in 4.28.3 are referred. The values A and B are to be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk and is to have at least the following minimum values:

	Nickel steels and carbon manganese steels	Austenitic steels	Aluminium alloys
A	3	3.5	4
B	1.5	1.5	1.5

4.23.3.2 Buckling criteria is to be as follows: the thickness and form of pressure vessels subject to external pressure and other loads causing compressive stresses are to be based on calculations using accepted pressure vessel buckling theory and are to adequately account for the difference in theoretical and actual buckling stress as a result of plate edge misalignment, ovality and deviation from true circular form over a specified arc or chord length.

4.23.4 *Fatigue design condition*

For large type C independent tanks, where the cargo at atmospheric pressure is below -55°C, IRS may require additional verification to check their compliance with 4.23.1.1 regarding static and dynamic stress.

4.23.5 Accident design condition

4.23.5.1 The tanks and the tank supporting structures are to be designed for the accidental loads and design conditions specified in 4.3.4.3 and 4.15, as applicable.

4.23.5.2 When subjected to the accidental loads specified in 4.15, the stress is to comply with the acceptance criteria specified in 4.23.3.1, modified as appropriate taking into account their lower probability of occurrence.

4.23.6 Testing

4.23.6.1 Each pressure vessel is to be subjected to a hydrostatic test at a pressure measured at the top of the tanks, of not less than 1.5 P_o. In no case during the pressure test shall the calculated primary membrane stress at any point exceed 90% of the yield stress of the material. To ensure that this condition is satisfied where calculations indicate that this stress will exceed 0.75 times the yield strength, the prototype test is to be monitored by the use of strain gauges or other suitable equipment in pressure vessels other than simple cylindrical and spherical pressure vessels.

4.23.6.2 The temperature of the water used for the test is to be at least 30 [°C] above the nil-ductility transition temperature of the material, as fabricated.

4.23.6.3 The pressure is to be held for 2 h per 25 mm of thickness, but in no case less than 2 h.

4.23.6.4 Where necessary for cargo pressure vessels, a hydropneumatic test may be carried out under the conditions prescribed in 4.23.6.1 to 4.23.6.3.

4.23.6.5 Special consideration may be given to the testing of tanks in which higher allowable stresses are used, depending on service temperature. However, the requirements of 4.23.6.1 are to be fully complied with.

4.23.6.6 After completion and assembly, each pressure vessel and its related fittings are to be subjected to an adequate tightness test which may be performed in combination with the pressure testing referred to in 4.23.6.1.

4.23.6.7 Pneumatic testing of pressure vessels other than cargo tanks are only to be considered on an individual case basis. Such testing is only to be permitted for those vessels designed or supported such that they cannot be safely filled with water, or for those vessels that cannot be dried and are to be used in a service where traces of the testing medium cannot be tolerated.

4.23.7 Marking

The required marking of the pressure vessel is to be achieved by a method that does not cause unacceptable local stress raisers.

4.24 Membrane tanks

4.24.1 Design basis

4.24.1.1 The design basis for membrane containment systems is that thermal and other expansion or contraction is compensated for without undue risk of losing the tightness of the membrane.

4.24.1.2 A systematic approach based on analysis and testing is to be used to demonstrate that the system will provide its intended function in consideration of the events identified in service as specified in 4.24.2.1.

4.24.1.3 If the cargo temperature at atmospheric pressure is below -10°C, a complete secondary barrier shall be provided as required in 4.5. The secondary barrier is to be designed according to 4.6.

4.24.1.4 The design vapour pressure P_o is normally not to exceed 0.025 [MPa]. If the hull scantlings are increased accordingly and consideration is given, where appropriate, to the strength of the supporting thermal insulation, P_o may be increased to a higher value, but less than 0.07 [MPa].

4.24.1.5 The definition of membrane tanks does not exclude designs such as those in which non-metallic membranes are used or where membranes are included or incorporated into the thermal insulation.

4.24.1.6 The thickness of the membranes is normally not to exceed 10 [mm].

4.24.1.7 The circulation of inert gas throughout the primary insulation space and the secondary insulation space, in accordance with 9.2.1, is to be sufficient to allow for effective means of gas detection.

4.24.2 Design considerations

4.24.2.1 Potential incidents that could lead to loss of fluid tightness over the life of the membranes is to be evaluated. These include, but are not limited to:

.1 Ultimate design events:

.1 tensile failure of membranes;

.2 compressive collapse of thermal insulation;

.3 thermal ageing;

.4 loss of attachment between thermal insulation and hull structure;

.5 loss of attachment of membranes to thermal insulation system;

.6 structural integrity of internal structures and their supporting structures; and

.7 failure of the supporting hull structure.

.2 Fatigue design events:

.1 fatigue of membranes including joints and attachments to hull structure;

.2 fatigue cracking of thermal insulation;

.3 fatigue of internal structures and their supporting structures; and

.4 fatigue cracking of inner hull leading to ballast water ingress.

.3 Accident design events:

.1 accidental mechanical damage (such as dropped objects inside the tank while in service);

.2 accidental overpressurization of thermal insulation spaces;

.3 accidental vacuum in the tank; and

.4 water ingress through the inner hull structure.

Designs where a single internal event could cause simultaneous or cascading failure of both membranes are unacceptable.

4.24.2.2 The necessary physical properties (mechanical, thermal, chemical, etc.) of the materials used in the construction of the cargo containment system are to be established during the design development in accordance with 4.24.1.2.

4.24.3 Loads and load combinations

Particular consideration is to be given to the possible loss of tank integrity due to either an overpressure in the interbarrier space, a possible vacuum in the cargo tank, the sloshing effects, hull vibration effects, or any combination of these events.

4.24.4 Structural analyses

4.24.4.1 Structural analyses and/or testing for the purpose of determining the ultimate strength and fatigue assessments of the cargo containment and associated structures, e.g. structures as defined in 4.9, are to be performed. The structural analysis is to provide the data required to assess each failure mode that has been identified as critical for the cargo containment system.

4.24.4.2 Structural analyses of the hull is to take into account the internal pressure as indicated in 4.13.2. Special attention is to be paid to deflections of the hull and their compatibility with the membrane and associated thermal insulation.

4.24.4.3 The analyses referred to in 4.24.4.1 and 4.24.4.2 are to be based on the particular motions, accelerations and response of ships and cargo containment systems.

4.24.5 Ultimate design condition

4.24.5.1 The structural resistance of every critical component, subsystem or assembly is to be established, in accordance with 4.24.1.2, for in-service conditions.

4.24.5.2 The choice of strength acceptance criteria for the failure modes of the cargo containment system, its attachments to the hull structure and internal tank structures, are to reflect the consequences associated with the considered mode of failure.

4.24.5.3 The inner hull scantlings are to meet the requirements for deep tanks, taking into account the internal pressure as indicated in 4.13.2 and the specified appropriate requirements for sloshing load as defined in 4.14.3.

4.24.6 Fatigue design condition

4.24.6.1 Fatigue analysis is to be carried out for structures inside the tank, i.e. pump towers, and for parts of membrane and pump tower attachments, where failure development cannot be reliably detected by continuous monitoring.

4.24.6.2 The fatigue calculations are to be carried out in accordance with 4.18.2, with relevant requirements depending on:

.1 the significance of the structural components with respect to structural integrity; and

.2 availability for inspection.

4.24.6.3 For structural elements for which it can be demonstrated by tests and/or analyses that a crack will not develop to cause simultaneous or cascading failure of both membranes, C_w is to be less than or equal to 0.5.

4.24.6.4 Structural elements subject to periodic inspection, and where an unattended fatigue crack can develop to cause simultaneous or cascading failure of both membranes, are to satisfy the fatigue and fracture mechanics requirements stated in 4.18.2.8.

4.24.6.5 Structural element not accessible for in-service inspection, and where a fatigue crack can develop without warning to cause simultaneous or cascading failure of both membranes, are to satisfy the fatigue and fracture mechanics requirements stated in 4.18.2.9.

4.24.7 Accident design condition

4.24.7.1 The containment system and the supporting hull structure are to be designed for the accidental loads specified in 4.15. These loads need not be combined with each other or with environmental loads.

4.24.7.2 Additional relevant accident scenarios are to be determined based on a risk analysis. Particular attention is to be paid to securing devices inside tanks.

4.24.8 Design development testing

4.24.8.1 The design development testing required in 4.24.1.2 is to include a series of analytical and physical models of both the primary and secondary barriers, including corners and joints, tested to verify that they will withstand the expected combined strains due to static, dynamic and thermal loads. This will culminate in the construction of a prototype-scaled model of the complete cargo containment system. Testing conditions considered in the analytical and physical models are to represent the most extreme service conditions the cargo containment system will be likely to encounter over its life. Proposed acceptance criteria for periodic testing of secondary barriers required in 4.6.2 may be based on the results of testing carried out on the prototype-scaled model.

4.24.8.2 The fatigue performance of the membrane materials and representative welded or bonded joints in the membranes are to be determined by tests. The ultimate strength and fatigue performance of arrangements for securing the thermal insulation system to the hull structure are to be determined by analyses or tests.

4.24.9 Testing

4.24.9.1 In ships fitted with membrane cargo containment systems, all tanks and other spaces that may normally contain liquid and are adjacent to the hull structure supporting the membrane, is to be hydrostatically tested.

4.24.9.2 All hold structures supporting the membrane are to be tested for tightness before installation of the cargo containment system.

4.24.9.3 Pipe tunnels and other compartments that do not normally contain liquid need not be hydrostatically tested.

4.25 Integral tanks

4.25.1 Design basis

Integral tanks that form a structural part of the hull and are affected by the loads that stress the adjacent hull structure are to comply with the following:

.1 the design vapour pressure P_o as defined in 4.1.2 is normally not to exceed 0.025 [MPa]. If the hull scantlings are increased accordingly, P_o may be increased to a higher value, but less than 0.07 [MPa];

.2 integral tanks may be used for products, provided the boiling point of the cargo is not below -10°C. A lower temperature may be accepted by IRS subject to special consideration, but in such cases a complete secondary barrier shall be provided; and

.3 products required by sec 19 to be carried in type 1G ships are not to be carried in integral tanks.

4.25.2 Structural analysis

The structural analysis of integral tanks is to be in accordance with recognized standards.

4.25.3 Ultimate design condition

4.25.3.1 The tank boundary scantlings are to meet the requirements for deep tanks, taking into account the internal pressure as indicated in 4.13.2.

4.25.3.2 For integral tanks, allowable stresses are normally to be those given for hull structure in the requirements of the IRS.

4.25.4 Accident design condition

4.25.4.1 The tanks and the tank supports are to be designed for the accidental loads specified in 4.3.4.3 and 4.15, as relevant.

4.25.4.2 When subjected to the accidental loads specified in 4.15, the stress is to comply with the acceptance criteria specified in 4.25.3, modified as appropriate, taking into account their lower probability of occurrence.

4.25.5 Testing

All integral tanks are to be hydrostatically or hydropneumatically tested. The test is to be performed so that the stresses approximate, as far as practicable, to the design stresses and that the pressure at the top of the tank corresponds at least to the MARVS.

4.26 Semi-membrane tanks

4.26.1 Design basis

4.26.1.1 Semi-membrane tanks are non-self-supporting tanks when in the loaded condition and consist of a layer, parts of which are supported through thermal insulation by the adjacent hull structure, whereas the rounded parts of this layer connecting the above-mentioned supported parts are designed also to accommodate the thermal and other expansion or contraction.

4.26.1.2 The design vapour pressure P_o is normally not to exceed 0.025 [MPa]. If the hull scantlings are increased accordingly, and consideration is given, where appropriate, to the strength of the supporting thermal insulation, P_o may be increased to a higher value, but less than 0.07 [MPa].

4.26.1.3 For semi-membrane tanks the relevant requirements in this section for independent tanks or for membrane tanks are to be applied as appropriate.

4.26.1.4 In the case of semi-membrane tanks that comply in all respects with the requirements applicable to type B independent tanks, except for the manner of support, the Administration/ IRS may, after special consideration, accept a partial secondary barrier.

Part F
Cargo containment systems of novel configuration

4.27 Limit state design for novel concepts

4.27.1 Cargo containment systems that are of a novel configuration that cannot be designed using sections 4.21 to 4.26 are to be designed using this section and parts A and B of this section, and also parts C and D, as applicable. Cargo containment system design according to this section shall be based on the principles of limit state design which is an approach to structural design that can be applied to established design solutions as well as novel designs. This more generic approach maintains a level of safety similar to that achieved for known containment systems as designed using 4.21 to 4.26.

4.27.2.1 The limit state design is a systematic approach where each structural element is evaluated with respect to possible failure modes related to the design conditions identified in 4.3.4. A limit state can be defined as a condition beyond which the structure, or part of a structure, no longer satisfies the requirements.

4.27.2.2 For each failure mode, one or more limit states may be relevant. By consideration of all relevant limit states, the limit load for the structural element is found as the minimum limit load resulting from all the relevant limit states. The limit states are divided into the three following categories:

.1 Ultimate limit states (ULS), which correspond to the maximum load-carrying capacity or, in some cases, to the maximum applicable strain or deformation; under intact (undamaged) conditions.

.2 Fatigue limit states (FLS), which correspond to degradation due to the effect of time varying (cyclic) loading.

.3 Accident limit states (ALS), which concern the ability of the structure to resist accidental situations.

4.27.3 The procedure and relevant design parameters of the limit state design are to comply with the Standards for the Use of limit state methodologies in the design of cargo containment systems of novel configuration (LSD Standard), as set out in appendix 5 of IGC Code.

Part G
Guidance

4.28 Guidance notes for Sec 4

4.28.1 Guidance to detailed calculation of internal pressure for static design purpose

4.28.1.1 This section provides guidance for the calculation of the associated dynamic liquid pressure for the purpose of static design calculations. This pressure may be used for determining the internal pressure referred to in 4.13.2.4, where:

.1 $(P_{gd})max$ is the associated liquid pressure determined using the maximum design accelerations.

.2 $(P_{gd}\ site)max$ is the associated liquid pressure determined using site specific accelerations.

.3 P_{eq} should be the greater of P_{eq1} and P_{eq2} calculated as follows:

$$P_{eq1} = P_o + (P_{gd})max \quad [MPa]$$

$$P_{eq2} = P_h + (P_{gd}site)max \quad [MPa]$$

4.28.1.2 The internal liquid pressures are those created by the resulting acceleration of the centre of gravity of the cargo due to the motions of the ship referred to in 4.14.1. The value of internal liquid pressure P_{gd} resulting from combined effects of gravity and dynamic accelerations should be calculated as follows:

$$P_{gd} = \alpha_\beta Z_\beta \frac{\rho}{1.02 \times 10^5} \quad [MPa]$$

Where:

α_β = dimensionless acceleration (i.e. relative to the acceleration of gravity), resulting from gravitational and dynamic loads, in an arbitrary direction β (see Fig.4.1).

For large tanks, an acceleration ellipsoid taking account of transverse vertical and longitudinal accelerations, should be used.

Z_β = largest liquid height (m) above the point where the pressure is to be determined measured from the tank shell in the β direction (see Fig.4.2).

Tank domes considered to be part of the accepted total tank volume shall be taken into account when determining Z_β , unless the total volume of tank domes V_d does not exceed the following value:

$$V_d = V_t\left(\frac{100 - FL}{FL}\right)$$

With:

V_t = tank volume without any domes; and

FL = filling limit according to Sec 15

ρ = maximum cargo density [kg/m^3] to the design temperature.

The direction that gives the maximum value (P_{gd})max or $(P_{gd}$site)max should be considered. The above formula applies only to full tanks.

4.28.1.3 Equivalent calculation procedures may be applied.

4.28.2 Guidance formulae for acceleration components

4.28.2.1 The following formulae are given as guidance for the components of acceleration due to ship's motions corresponding to a probability level of 10^{-8} in the North Atlantic and apply to ships with a length exceeding 50 m and at or near their service speed:

- Vertical acceleration, as defined in 4.14.1:

$$a_z = \pm a_0 \sqrt{1 + \left(5.3 - \frac{45}{L_0}\right)^2 \left(\frac{x}{L_0} + 0.05\right)^2 \left(\frac{0.6}{C_B}\right)^{1.5} + \left(\frac{0.6yK^{1.5}}{B}\right)^2}$$

- Transverse acceleration, as defined in 4.14.1:

$$a_y = \pm a_0 \sqrt{0.6 + 2.5\left(\frac{x}{L_0} + 0.05\right)^2 + K\left(1 + 0.6K\frac{z}{B}\right)^2}$$

- Longitudinal acceleration, as defined in 4.14.1:

$$a_y = \pm a_0 \sqrt{0.06 + A^2 - 0.25A}$$

Where:

$$a_0 = 0.2\frac{V}{\sqrt{L_0}} + \frac{34 - \left(\frac{600}{L_0}\right)}{L_0}$$

L_0 = length of the ship for determination of scantlings as defined in recognized standards (m);

C_B = block coefficient;

B = greatest moulded breadth of the ship (m);

x = longitudinal distance (m) from amidships to the centre of gravity of the tank with contents; x is positive forward of amidships, negative aft of amidships;

y = transverse distance (m) from centreline to the centre of gravity of the tank with contents;

z = vertical distance (m) from the ship's actual waterline to the centre of gravity of tank with contents; z is positive above and negative below the waterline;

K = 1 in general. For particular loading conditions and hull forms, determination of K according to the following formula may be necessary:

$K = 13GM/B$, where $K \geq 1$ and GM = metacentric height (m);

$$A = \left(0.7 - \frac{L_0}{1200} + 5\frac{z}{L_0}\right)\left(\frac{0.6}{C_B}\right); \text{ and}$$

V = service speed (knots);

a_x, a_y, a_z = maximum dimensionless accelerations (i.e. relative to the acceleration of gravity) in the respective directions. They are considered as acting separately for calculation purposes, and a_z does not include the component due to the static weight, a_y includes the component due to the static weight in the transverse direction due to rolling and a_x includes the component due to the static weight in the longitudinal direction due to pitching. The accelerations derived from the above formulae are applicable only to ships at or near their service speed, not while at anchor or otherwise near stationary in exposed locations.

4.28.3 Stress categories

4.28.3.1 For the purpose of stress evaluation, stress categories are defined in this section as follows.

4.28.3.2 Normal stress is the component of stress normal to the plane of reference.

4.28.3.3 Membrane stress is the component of normal stress that is uniformly distributed and equal to the average value of the stress across the thickness of the section under consideration.

4.28.3.4 Bending stress is the variable stress across the thickness of the section under consideration, after the subtraction of the membrane stress.

4.28.3.5 Shear stress is the component of the stress acting in the plane of reference.

4.28.3.6 Primary stress is a stress produced by the imposed loading, which is necessary to balance the external forces and moments. The basic characteristic of a primary stress is that it is not self-limiting. Primary stresses that considerably exceed the yield strength will result in failure or at least in gross deformations.

4.28.3.7 Primary general membrane stress is a primary membrane stress that is so distributed in the structure that no redistribution of load occurs as a result of yielding.

4.28.3.8 Primary local membrane stress arises where a membrane stress produced by pressure or other mechanical loading and associated with a primary or a discontinuity effect produces excessive distortion in the transfer of loads for other portions of the structure. Such a stress is classified as a primary local membrane stress, although it has some characteristics of a secondary stress. A stress region may be considered as local, if:

$S_1 \leq 0.5\sqrt{Rt}$
and
$S_2 \geq 2.5\sqrt{Rt}$

Where:

S_1 = distance in the meridional direction over which the equivalent stress exceeds 1.1f;

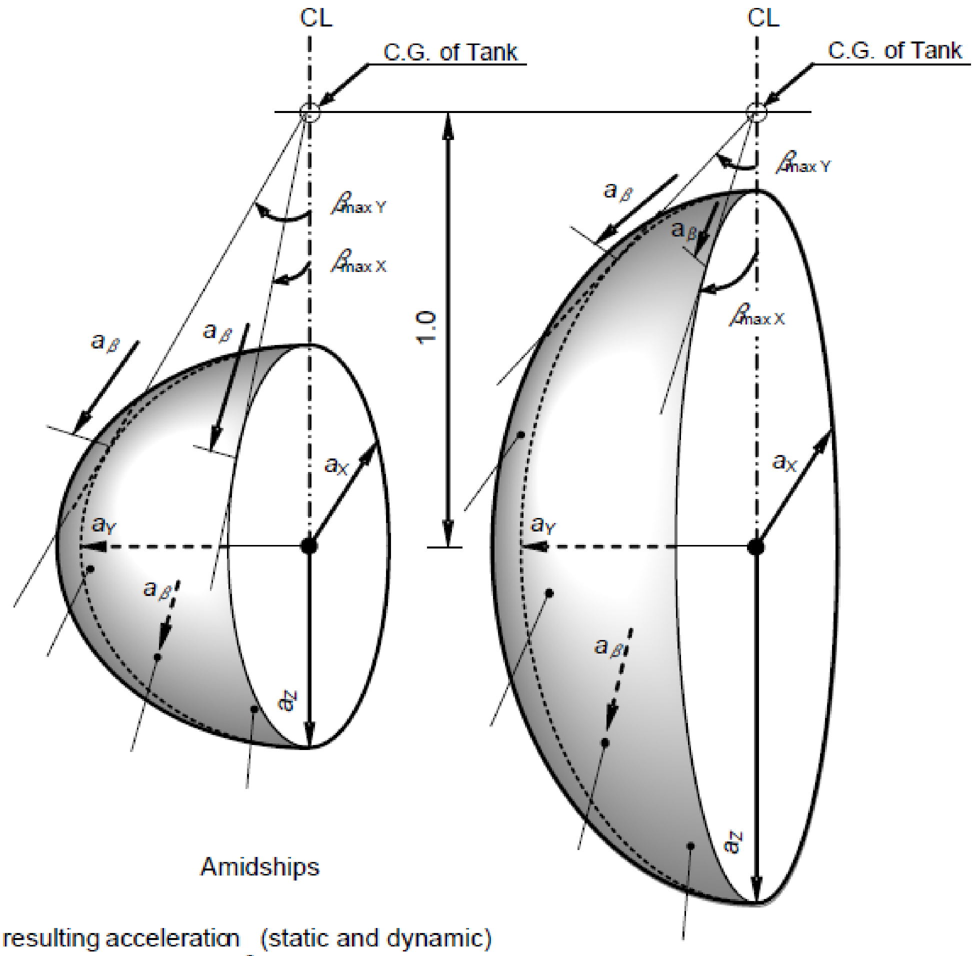
S_2 = distance in the meridional direction to another region where the limits for primary general membrane stress are exceeded;

R = mean radius of the vessel;

t = wall thickness of the vessel at the location where the primary general membrane stress limit is exceeded; and

f = allowable primary general membrane stress.

4.28.3.9 Secondary stress is a normal stress or shear stress developed by constraints of adjacent parts or by self-constraint of a structure. The basic characteristic of a secondary stress is that it is self-limiting. Local yielding and minor distortions can satisfy the conditions that cause the stress to occur.



Amidships

At 0.05L from FP

a_β = resulting acceleration (static and dynamic) in arbitrary direction β

a_X = longitudinal component of acceleration

a_Y = transverse component of acceleration

a_Z = vertical component of acceleration

Figure 4.1 – Acceleration ellipsoid

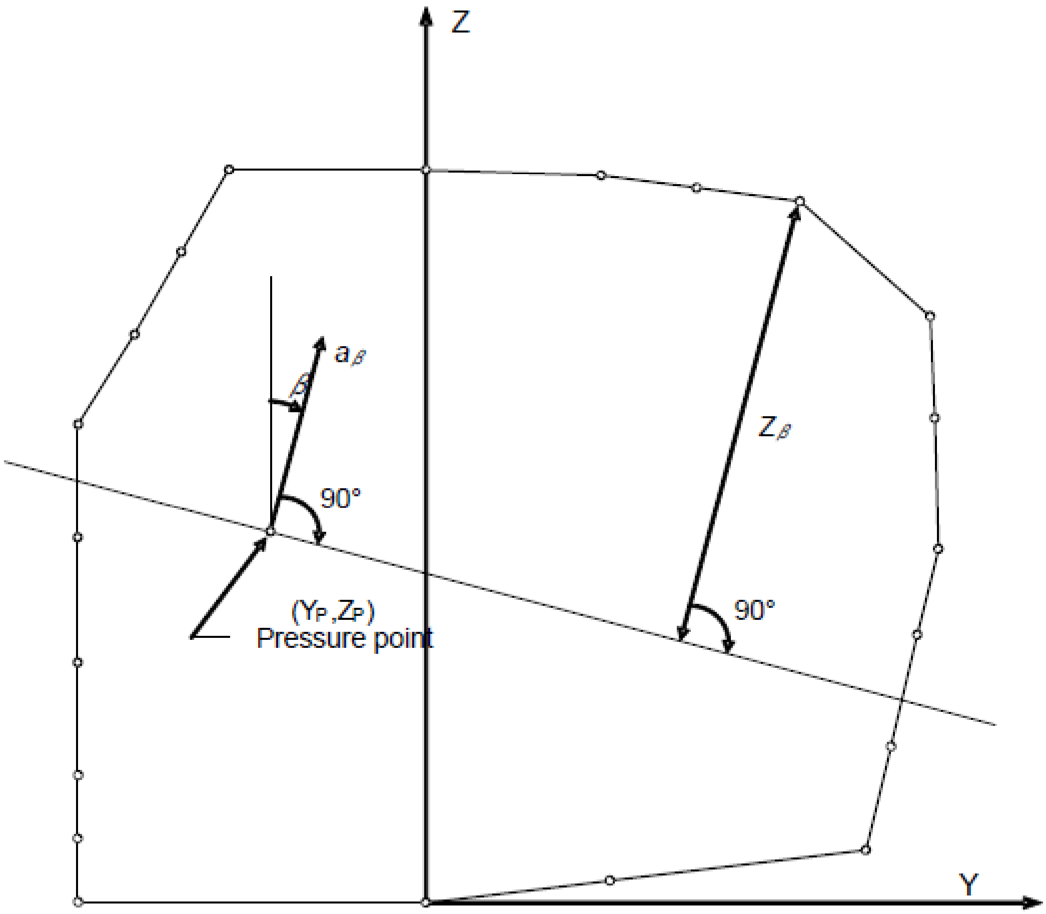


Figure 4.2 – Determination of internal pressure heads

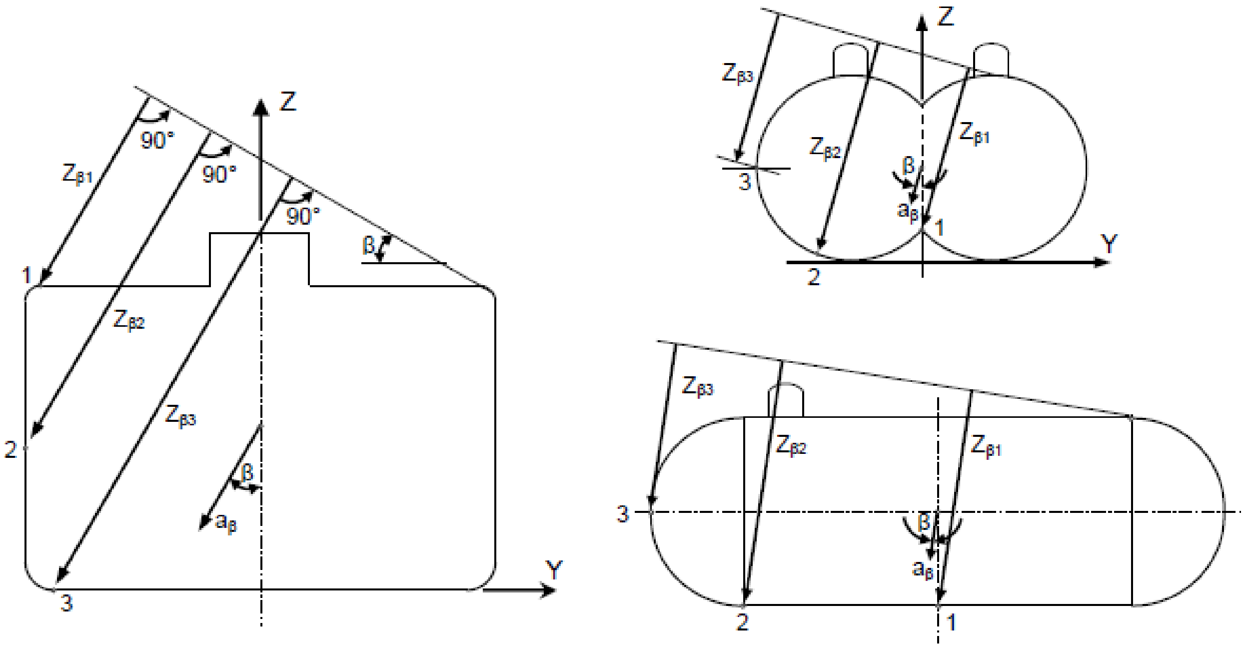


Figure 4.3 – Determination of liquid height Z_β for points 1, 2 and 3

Section 5

Process Pressure Vessels and Liquid, Vapour and Pressure Piping Systems

5.0 Goal

To ensure the safe handling of all cargo and process liquid and vapour, under all operating conditions, to minimize the risk to the ship, crew and to the environment, having regard to the nature of the products involved. This will:

.1 ensure the integrity of process pressure vessels, piping systems and cargo hoses;

.2 prevent the uncontrolled transfer of cargo;

.3 ensure reliable means to fill and empty the containment systems; and

.4 prevent pressure or vacuum excursions of cargo containment systems, beyond design parameters, during cargo transfer operations.

5.1 General

IR 5.1.1 Process pressure vessels and piping systems are to comply with the relevant Chapters of Pt.4.

5.1.1 The requirements of this section apply to products and process piping, including vapour piping, gas fuel piping and vent lines of safety valves or similar piping. Auxiliary piping systems not containing cargo are exempt from the general requirements of this section.

5.1.2 The requirements for Type C independent tanks provided in Sec.4 may also apply to process pressure vessels. If so required, the term "pressure vessels" as used in Sec.4 cover both Type C independent tanks and process pressure vessels.

5.1.3 Process pressure vessels include surge tanks, heat exchangers and accumulators that store or treat liquid or vapour cargo.

5.2 System requirements

5.2.1 The cargo handling and cargo control systems are to be designed taking into account the following:

.1 prevention of an abnormal condition escalating to a release of liquid or vapour cargo;

.2 the safe collection and disposal of cargo fluids released;

.3 prevention of the formation of flammable mixtures;

.4 prevention of ignition of flammable liquids or gases and vapours released; and

.5 limiting the exposure of personnel to fire and other hazards.

5.2.2 Arrangements: general

5.2.2.1 Any piping system that may contain cargo liquid or vapour is to:

.1 be segregated from other piping systems, except where interconnections are required for cargo-related operations such as purging, gas-freeing or inerting. The requirements of 9.4.4 shall be taken into account with regard to preventing back-flow of cargo. In such cases, precautions are to be taken to ensure that cargo or cargo vapour cannot enter other piping systems through the interconnections;

.2 except as provided in sec 16, not pass through any accommodation space, service space or control station or through a machinery space other than a cargo machinery space;

.3 be connected to the cargo containment system directly from the weather decks except where pipes installed in a vertical trunkway or equivalent are used to traverse void spaces above a cargo containment system and except where pipes for drainage, venting or purging traverse cofferdams;

.4 be located in the cargo area above the weather deck except for bow or stern loading and unloading arrangements in accordance with 3.8, emergency cargo jettisoning piping systems in accordance with 5.3.1, turret compartment systems in accordance with 5.3.3 and except in accordance with sec 16; and

.5 be located inboard of the transverse tank location requirements of 2.4.1, except for athwartship shore connection piping not subject to internal pressure at sea or emergency cargo jettisoning piping systems.

5.2.2.2 Suitable means is to be provided to relieve the pressure and remove liquid cargo from loading and discharging crossover headers; likewise, any piping between the outermost manifold valves and loading arms or cargo hoses to the cargo tanks, or other suitable location, prior to disconnection.

5.2.2.3 Piping systems carrying fluids for direct heating or cooling of cargo are not to be led outside the cargo area unless a suitable means is provided to prevent or detect the migration of cargo vapour outside the cargo area (see 13.6.2.6).

5.2.2.4 Relief valves discharging liquid cargo from the piping system are to discharge into the cargo tanks. Alternatively, they may discharge to the cargo vent mast, if means are provided to detect and dispose of any liquid cargo that may flow into the vent system. Where required to prevent overpressure in downstream piping, relief valves on cargo pumps are to discharge to the pump suction.

5.3 Arrangements for cargo piping outside the cargo area

5.3.1 Emergency cargo jettisoning

If fitted, an emergency cargo jettisoning piping system is to comply with 5.2.2, as appropriate, and may be led aft, external to accommodation spaces, service spaces or control stations or machinery spaces, but is not to pass through them. If an emergency cargo jettisoning piping system is permanently installed, a suitable means of isolating the piping system from the cargo piping is to be provided within the cargo area.

5.3.2 Bow and stern loading arrangements

5.3.2.1 Subject to the requirements of 3.8, this section and 5.10.1, cargo piping may be arranged to permit bow or stern loading and unloading.

5.3.2.2 Arrangements are to be made to allow such piping to be purged and gas-freed after use. When not in use, the spool pieces are to be removed and the pipe ends blank-flanged. The vent pipes connected with the purge is to be located in the cargo area.

5.3.3 Turret compartment transfer systems

For the transfer of liquid or vapour cargo through an internal turret arrangement located outside the cargo area, the piping serving this purpose is to comply with 5.2.2, as applicable, 5.10.2 and the following:

.1 piping are to be located above the weather deck, except for the connection to the turret;

.2 portable arrangements are not to be permitted; and

.3 arrangements are to be made to allow such piping to be purged and gas-freed after use. When not in use, the spool pieces for isolation from the cargo piping are to be removed and the pipe ends blank-flanged. The vent pipes connected with the purge are to be located in the cargo area.

5.3.4 Gas fuel piping systems

Gas fuel piping in machinery spaces are to comply with all applicable clauses of this section in addition to the requirements of sec 16.

5.4 Design pressure

5.4.1 The design pressure P_o, used to determine minimum scantlings of piping and piping system components, are not to be less than the maximum gauge pressure to which the system may be subjected in service. The minimum design pressure used is not to be less than 1 [MPa] gauge, except for open-ended lines or pressure relief valve discharge lines, where it is not to be less than the lower of 0.5 [MPa] gauge, or 10 times the relief valve set pressure.

5.4.2 The greater of the following design conditions are to be used for piping, piping systems and components, based on the cargoes being carried:

.1 for vapour piping systems or components that may be separated from their relief valves and which may contain some liquid, the saturated vapour pressure at a design temperature of 45 [°C]. Higher or lower values may be used (see 4.13.2.2); or

.2 for systems or components that may be separated from their relief valves and which contain only vapour at all times, the superheated vapour pressure at 45°C. Higher or lower values may be used (see 4.13.2.2), assuming an initial condition of saturated vapour in the system at the system operating pressure and temperature; or

.3 the MARVS of the cargo tanks and cargo processing systems; or

.4 the pressure setting of the associated pump or compressor discharge relief valve; or

.5 the maximum total discharge or loading head of the cargo piping system considering all possible pumping arrangements or the relief valve setting on a pipeline system.

5.4.3 Those parts of the liquid piping systems that may be subjected to surge pressures are to be designed to withstand this pressure.

5.4.4 The design pressure of the outer pipe or duct of gas fuel systems is not to be less than the maximum working pressure of the inner gas pipe. Alternatively, for gas fuel piping systems with a working pressure greater than 1 [MPa], the design pressure of the outer duct is not to be less than the maximum built-up pressure arising in the annular space considering the local instantaneous peak pressure in way of any rupture and the ventilation arrangements.

5.5 Cargo system valve requirements

5.5.1.1 Every cargo tank and piping system is to be fitted with manually operated valves for isolation purposes as specified in this sub-section.

5.5.1.2 In addition, remotely operated valves are also to be fitted, as appropriate, as part of the emergency shutdown (ESD) system the purpose of which is to stop cargo flow or leakage in the event of an emergency when cargo liquid or vapour transfer is in progress. The ESD system is intended to return the cargo system to a safe static condition so that any remedial action can be taken. Due regard is to be given in the design of the ESD system to avoid the generation of surge pressures within the cargo transfer pipework. The equipment to be shut down on ESD activation includes manifold valves during loading or discharge, any pump or compressor, etc., transferring cargo internally or externally (e.g. to shore or another ship/barge) and cargo tank valves, if the MARVS exceeds 0.07 [MPa].

5.5.2 Cargo tank connections

5.5.2.1 All liquid and vapour connections, except for safety relief valves and liquid level gauging devices, are to have shutoff valves located as close to the tank as practicable. These valves are to provide full closure and are to be capable of local manual operation. They may also be capable of remote operation.

5.5.2.2 For cargo tanks with a MARVS exceeding 0.07 [MPa] gauge, the above connections are also to be equipped with remotely controlled ESD valves. These valves are to be located as close to the tank as practicable. A single valve may be substituted for the two separate valves, provided the valve complies with the requirements of 18.10.2 and provides full closure of the line.

5.5.3 Cargo manifold connections

5.5.3.1 One remotely controlled ESD valve is to be provided at each cargo transfer connection in use to stop liquid and vapour transfer to or from the ship. Transfer connections not in use are to be isolated with suitable blank flanges.

5.5.3.2 If the cargo tank MARVS exceeds 0.07 [MPa], an additional manual valve is to be provided for each transfer connection in use, and may be inboard or outboard of the ESD valve to suit the ship's design.

5.5.4 Excess flow valves may be used in lieu of ESD valves, if the diameter of the protected pipe does not exceed 50 [mm]. Excess flow valves are to close automatically at the rated closing flow of vapour or liquid as specified by the manufacturer. The piping including fittings, valves and appurtenances protected by an excess flow valve is to have a capacity greater than the rated closing flow of the excess flow valve. Excess flow valves may be designed with a bypass not exceeding the area of a 1 [mm] diameter circular opening to allow equalization of pressure after a shutdown activation.

5.5.5 Cargo tank connections for gauging or measuring devices need not be equipped with excess flow valves or ESD valves, provided that the devices are constructed so that the outward flow of tank contents cannot exceed that passed by a 1.5 [mm] diameter circular hole.

5.5.6 All pipelines or components which may be isolated in a liquid full condition are to be protected with relief valves for thermal expansion and evaporation.

5.5.7 All pipelines or components which may be isolated automatically due to a fire with a liquid volume of more than 0.05 [m^3] entrapped are to be provided with PRVs sized for a fire condition.

5.6 Cargo transfer arrangements

5.6.1 Where cargo transfer is by means of cargo pumps that are not accessible for repair with the tanks in service, at least two separate means are to be provided to transfer cargo from each cargo tank, and the design is to be such that failure of one cargo pump or means of transfer will not prevent the cargo transfer by another pump or pumps, or other cargo transfer means.

5.6.2 The procedure for transfer of cargo by gas pressurization is to preclude lifting of the relief valves during such transfer. Gas pressurization may be accepted as a means of transfer of cargo for those tanks where the design factor of safety is not reduced under the conditions prevailing during the cargo transfer operation. If the cargo tank relief valves or set pressure are changed for this purpose, as it is permitted in accordance with 8.2.7 and 8.2.8, the new set pressure is not to exceed P_h as is defined in 4.13.2.

5.6.3 Vapour return connections

Connections for vapour return to the shore installations are to be provided.

5.6.4 Cargo tank vent piping systems

The pressure relief system is to be connected to a vent piping system designed to minimize the possibility of cargo vapour accumulating on the decks, or entering accommodation spaces, service spaces, control stations and machinery spaces, or other spaces where it may create a dangerous condition.

5.6.5 Cargo sampling connections

5.6.5.1 Connections to cargo piping systems for taking cargo liquid samples are to be clearly marked and are to be designed to minimize the release of cargo vapours. For vessels permitted to carry toxic products, the sampling system is to be of a closed loop design to ensure that cargo liquid and vapour are not vented to atmosphere.

5.6.5.2 Liquid sampling systems are to be provided with two valves on the sample inlet. One of these valves is to be of the multi-turn type to avoid accidental opening, and is to be spaced far enough apart to ensure that they can isolate the line if there is blockage, by ice or hydrates for example.

5.6.5.3 On closed loop systems, the valves on the return pipe is also to comply with 5.6.5.2.

5.6.5.4 The connection to the sample container is to comply with recognized standards and be supported so as to be able to support the weight of a sample container. Threaded connections are to be tack-welded, or otherwise locked, to prevent them being unscrewed during the normal connection and disconnection of sample containers. The sample connection is to be fitted with a closure plug or flange to prevent any leakage when the connection is not in use.

5.6.5.5 Sample connections used only for vapour samples may be fitted with a single valve in accordance with 5.5, 5.8 and 5.13, and is also to be fitted with a closure plug or flange.

5.6.5.6 Sampling operations are to be undertaken as prescribed in 18.9.

5.6.6 Cargo filters

The cargo liquid and vapour systems are to be capable of being fitted with filters to protect against damage by extraneous objects. Such filters may be permanent or temporary, and the standards of filtration are to be appropriate to the risk of debris, etc., entering the cargo system. Means are to be provided to indicate that filters are becoming blocked, and to isolate, depressurize and clean the filters safely.

5.7 Installation requirements

5.7.1 Design for expansion and contraction

Provision is to be made to protect the piping, piping system and components and cargo tanks from excessive stresses due to thermal movement and from movements of the tank and hull structure. The preferred method outside the cargo tanks is by means of offsets, bends or loops, but multi-layer bellows may be used if offsets, bends or loops are not practicable.

5.7.2 Precautions against low temperature

Low temperature piping is to be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material. Where liquid piping is dismantled regularly, or where liquid leakage may be anticipated, such as at shore connections and at pump seals, protection for the hull beneath is to be provided.

5.7.3 Water curtain

For cargo temperatures below -110 [°C], a water distribution system is to be fitted in way of the hull under the shore connections to provide a low-pressure water curtain for additional protection of the hull steel and the ship's side structure. This system is in addition to the requirements of 11.3.1.4, and is to be operated when cargo transfer is in progress.

5.7.4 Bonding

Where tanks or cargo piping and piping equipment are separated from the ship's structure by thermal isolation, provision is to be made for electrically bonding both the piping and the tanks. All gasketed pipe joints and hose connections are to be electrically bonded. Except where bonding straps are used, it is to be demonstrated that the electrical resistance of each joint or connection is less than 1MΩ.

5.8 Piping fabrication and joining details

5.8.1 General

The requirements of this sub-section apply to piping inside and outside the cargo tanks. Relaxation from these requirements may be accepted, in accordance with recognized standards for piping inside cargo tanks and open-ended piping.

5.8.2 Direct connections

The following direct connection of pipe lengths, without flanges, may be considered:

> .1 butt-welded joints with complete penetration at the root may be used in all applications. For design temperatures colder than -10 [°C], butt welds shall be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas backup on the first pass. For design pressures in excess of 1 [MPa] and design temperatures of -10 [°C] or colder, backing rings shall be removed;
>
> .2 slip-on welded joints with sleeves and related welding, having dimensions in accordance with recognized standards, are only to be used for instrument lines and open-ended lines with an external diameter of 50 [mm] or less and design temperatures not colder than -55 [°C]; and
>
> .3 screwed couplings complying with recognized standards are only to be used for accessory lines and instrumentation lines with external diameters of 25 [mm] or less.

5.8.3 Flanged connections

5.8.3.1 Flanges in flanged connections are to be of the welded neck, slip-on or socket welded type.

5.8.3.2 Flanges are to comply with recognized standards for their type, manufacture and test. For all piping, except open ended, the following restrictions apply:

> .1 for design temperatures colder than -55 [°C], only welded-neck flanges are to be used; and
>
> .2 for design temperatures colder than -10 [°C], slip-on flanges are not to be used in nominal sizes above 100 [mm] and socket welded flanges are not to be used in nominal sizes above 50 [mm].

5.8.4 Expansion joints

Where bellows and expansion joints are provided in accordance with 5.7.1, the following requirements apply:

> .1 if necessary, bellows are to be protected against icing; and
>
> .2 slip joints are not to be used except within the cargo tanks.

5.8.5 Other connections

Piping connections are to be joined in accordance with 5.8.2 to 5.8.4, but for other exceptional cases the Administration/ IRS may consider alternative arrangements.

5.9 Welding, post-weld heat treatment and non-destructive testing

5.9.1 General

Welding is to be carried out in accordance with 6.5.

5.9.2 Post-weld heat treatment

Post-weld heat treatment is to be required for all butt welds of pipes made with carbon, carbon-manganese and low alloy steels. IRS may waive the requirements for thermal stress relieving of pipes with wall thickness less than 10 [mm] in relation to the design temperature and pressure of the piping system concerned.

5.9.3 Non-destructive testing

In addition to normal controls before and during the welding, and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly and according to the requirements of this paragraph, the following tests shall be required:

.1 100% radiographic or ultrasonic inspection of butt-welded joints for piping systems with design temperatures colder than -10 [°C], or with inside diameters of more than 75 [mm], or wall thicknesses greater than 10 [mm];

.2 when such butt-welded joints of piping sections are made by automatic welding procedures approved by IRS, then a progressive reduction in the extent of radiographic or ultrasonic inspection can be agreed, but in no case to less than 10% of each joint. If defects are revealed, the extent of examination is to be increased to 100% and is to include inspection of previously accepted welds. This approval can only be granted if well-documented quality assurance procedures and records are available to assess the ability of the manufacturer to produce satisfactory welds consistently; and

.3 for other butt-welded joints of pipes not covered by 5.9.3.1 and 5.9.3.2, spot radiographic or ultrasonic inspection or other non-destructive tests are to be carried out depending upon service, position and materials. In general, at least 10% of butt-welded joints of pipes are to be subjected to radiographic or ultrasonic inspection.

5.10 Installation requirements for cargo piping outside the cargo area

5.10.1 Bow and stern loading arrangements

The following requirements shall apply to cargo piping and related piping equipment located outside the cargo area:

.1 cargo piping and related piping equipment outside the cargo area are to have only welded connections. The piping outside the cargo area are to run on the weather decks and are to be at least 0.8 [m] inboard, except for athwartships shore connection piping. Such piping is to be clearly identified and fitted with a shutoff valve at its connection to the cargo piping system within the cargo area. At this location, it is also to be capable of being separated by means of a removable spool piece and blank flanges, when not in use; and

.2 the piping are to be full penetration butt-welded and subjected to full radiographic or ultrasonic inspection, regardless of pipe diameter and design temperature. Flange connections in the piping are only to be permitted within the cargo area and at the shore connection.

5.10.2 Turret compartment transfer systems

The following requirements shall apply to liquid and vapour cargo piping where it is run outside the cargo area:

.1 cargo piping and related piping equipment outside the cargo area are to have only welded connections; and

.2 the piping are to be full penetration butt-welded, and subjected to full radiographic or ultrasonic inspection, regardless of pipe diameter and design temperature. Flange connections in the piping are only to be permitted within the cargo area and at connections to cargo hoses and the turret connection.

5.10.3 Gas fuel piping

Gas fuel piping, as far as practicable, are to have welded joints. Those parts of the gas fuel piping that are not enclosed in a ventilated pipe or duct according to 16.4.3, and are on the weather decks outside the cargo area, are to have full penetration butt-welded joints and are to be subjected to full radiographic or ultrasonic inspection.

5.11 Piping system component requirements

5.11.1 Piping scantlings.

Piping systems are to be designed in accordance with recognized standards.

5.11.2.1 The following criteria are to be used for determining pipe wall thickness.

5.11.2.2 The wall thickness of pipes is not to be less than:

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}} \qquad [mm]$$

Where:

t_0 = theoretical thickness, determined by the following formula:

$$t_0 = \frac{P\ D}{2K\ e + P} \qquad [mm]$$

With:

P = design pressure [MPa] referred to in 5.4;

D = outside diameter [mm];

K = allowable stress [N/mm^2] referred to in 5.11.3;

e = efficiency factor equal to 1 for seamless pipes and for longitudinally or spirally welded pipes, that are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with recognized standards. In other cases, an efficiency factor of less than 1, in accordance with recognized standards, may be required, depending on the manufacturing process;

b= allowance for bending [mm].The value of b is to be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b is to be:

$$b = \frac{D\ t_0}{2.5r} \qquad [mm]$$

With:

r = mean radius of the band [mm];

c = corrosion allowance [mm]. If corrosion or erosion is expected, the wall thickness of the piping is to be increased over that required by the other design requirements. This allowance is to be consistent with the expected life of the pricing; and

a = negative manufacturing tolerance for thickness (%).

5.11.2.3 The minimum wall thickness is to be in accordance with recognized standards.

5.11.2.4 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads, the wall thickness shall be increased over that required by 5.11.2.2 or, if this is impracticable or would cause excessive local stresses, these loads may be reduced, protected against or eliminated by other design methods. Such superimposed loads may be due to: supporting structures, ship deflections, liquid pressure surge during transfer operations, the weight of suspended valves, reaction to loading arm connections, or otherwise.

5.11.3 Allowable stress

5.11.3.1 For pipes, the allowable stress K referred to in the formula in 5.11.2 is the lower of the following values:

$$\frac{R_m}{A} \ or \ \frac{R_e}{B}$$

Where:

R_m = specified minimum tensile strength at room temperature [N/mm^2]; and

R_e = specified minimum yield stress at room temperature [N/mm^2]. If the stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies.

The values of A and B are to be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required in

1.4.4, and have values of at least A = 2.7 and B = 1.8.

5.11.4 High-pressure gas fuel outer pipes or ducting scantlings

In fuel gas piping systems of design pressure greater than the critical pressure, the tangential membrane stress of a straight section of pipe or ducting shall not exceed the tensile strength divided by 1.5 (R_m /1.5) when subjected to the design pressure specified in 5.4. The pressure ratings of all other piping components are to reflect the same level of strength as straight pipes.

5.11.5 Stress analysis

When the design temperature is -110 [°C] or lower, a complete stress analysis, taking into account all the stresses due to the weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship for each branch of the piping system is to be submitted. For temperatures above -110 [°C], a stress analysis may be required by IRS in relation to such matters as the design or stiffness of the piping system and the choice of materials. In any case, consideration is to be given to thermal stresses even though calculations are not submitted. The analysis may be carried out according to a code of practice acceptable to IRS.

5.11.6 Flanges, valves and fittings

5.11.6.1 Flanges, valves and other fittings are to comply with recognized standards, taking into account the material selected and the design pressure defined in 5.4. For bellows expansion joints used in vapour service, a lower minimum design pressure may be accepted.

5.11.6.2 For flanges not complying with a recognized standard, the dimensions of flanges and related bolts are to be to the satisfaction of IRS.

5.11.6.3 All emergency shutdown valves are to be of the "fire closed" type (see 5.13.1.1 and 18.10.2).

5.11.6.4 The design and installation of expansion bellows are to be in accordance with recognized standards and be fitted with means to prevent damage due to over-extension or compression.

5.11.7 Ship's cargo hoses

5.11.7.1 Liquid and vapour hoses used for cargo transfer are to be compatible with the cargo and suitable for the cargo temperature.

5.11.7.2 Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, are to be designed for a bursting pressure not less than five times the maximum pressure the hose will be subjected to during cargo transfer.

5.11.7.3 Each new type of cargo hose, complete with end-fittings, is to be prototype-tested at a normal ambient temperature, with 200 pressure cycles from zero to at least twice the specified maximum working pressure. After this cycle pressure test has been carried out, the prototype test is to demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the upper and lower extreme service temperature. Hoses used for prototype testing is not to be used for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced is to be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure, but not more than two fifths of its bursting pressure. The hose is to be stencilled, or otherwise marked, with the date of testing, its specified maximum working pressure and, if used in services other than ambient temperature services, its maximum and minimum service temperature, as applicable. The specified maximum working pressure is not to be less than 1 [MPa] gauge.

5.12 Materials

5.12.1 The choice and testing of materials used in piping systems are to comply with the requirements of Sec 6, taking into account the minimum design temperature. However, some relaxation may be permitted in the quality of material of open-ended vent piping, provided that the temperature of the cargo at the pressure relief valve setting is not lower than -55 [°C], and that no liquid discharge to the vent piping can occur. Similar relaxations may be permitted under the same temperature conditions to open-ended piping inside cargo tanks, excluding discharge piping and all piping inside membrane and semi-membrane tanks.

5.12.2 Materials having a melting point below 925 [°C] are not to be used for piping outside the cargo tanks except for short lengths of pipes attached to the cargo tanks, in which case fire-resisting insulation is to be provided.

5.12.3 Cargo piping insulation system

5.12.3.1 Cargo piping systems are to be provided with a thermal insulation system as required to minimize heat leak into the cargo during transfer operations and to protect personnel from direct contact with cold surfaces.

5.12.3.2 Where applicable, due to location or environmental conditions, insulation materials are to have suitable properties of resistance to fire and flame spread and is to be adequately protected against penetration of water vapour and mechanical damage.

5.12.4 Where the cargo piping system is of a material susceptible to stress corrosion cracking in the presence of a salt-laden atmosphere, adequate measures to avoid this occurring is to be taken by considering material selection, protection of exposure to salty water and/or readiness for inspection.

5.13 Testing requirements

5.13.1 Type testing of piping components

5.13.1.1 Valves

Each type of valve intended to be used at a working temperature below -55 [^{o}C] is to be subject to the following type tests:

.1 each size and type of valve is to be subjected to seat tightness testing over the full range of operating pressures for bi-directional flow and temperatures, at intervals, up to the rated design pressure of the valve. Allowable leakage rates are to be to the requirements of IRS. During the testing, satisfactory operation of the valve is to be verified;

.2 the flow or capacity is to be certified to a recognized standard for each size and type of valve;

.3 pressurized components are to be pressure tested to at least 1.5 times the rated pressure; and

.4 for emergency shutdown valves, with materials having melting temperatures lower than 925 [°C], the type testing is to include a fire test to a standard acceptable to the Administration/ IRS.

5.13.1.2 Expansion bellows

The following type tests are to be performed on each type of expansion bellows intended for use on cargo piping outside the cargo tank and where required by IRS, on those installed within the cargo tanks:

.1 elements of the bellows, not pre-compressed, are to be pressure tested at not less than five times the design pressure without bursting. The duration of the test is not to be less than 5 [min];

.2 a pressure test is to be performed on a type expansion joint, complete with all the accessories such as flanges, stays and articulations, at the minimum design temperature and twice the design pressure at the extreme displacement conditions recommended by the manufacturer, without permanent deformation;

.3 a cyclic test (thermal movements) is to be performed on a complete expansion joint, which is to withstand at least as many cycles under the conditions of pressure, temperature, axial movement, rotational movement and transverse movement as it will encounter in actual service. Testing at ambient temperature is permitted when this testing is at least as severe as testing at the service temperature; and

.4 a cyclic fatigue test (ship deformation) is to be performed on a complete expansion joint, without internal pressure, by simulating the bellows movement corresponding to a compensated pipe length, for at least 2,000,000 cycles at a frequency not higher than 5 [Hz]. This test is only required when, due to the piping arrangement, ship deformation loads are actually experienced.

IR5.13.1.3 Cargo pumps

IR5.13.1.3.1 Prototype testing

Each size and type of pump is to be approved through design assessment and prototype testing. Prototype testing is to be witnessed by the Surveyor. Consideration may be given to acceptance of satisfactory in service experience report submitted by the manufacturer, for a class approved existing pump design.

Prototype testing is to include hydrostatic test of the pump body equal to 1.5 times the design pressure and a capacity test. For submerged electric motor driven pumps, the capacity test is to be carried out with the design fluid or with a fluid below the minimum working temperature. For shaft driven deep well pumps, the capacity test may be carried out with water. In addition, for shaft driven deep well pumps, a spin test to demonstrate satisfactory operation of bearing clearances, wear rings and sealing arrangements is to be carried out at the minimum design temperature. The full length of shafting is not required for the spin test, but must be of sufficient length to include at least one bearing and sealing arrangements. After completion of tests, the pump is to be opened out for examination.

IR5.13.1.3.2 Unit production testing

All pumps are to be tested at the plant of manufacturer in the presence of the Surveyor. Testing is to include hydrostatic test of the pump body equal to 1.5 times the design pressure and a capacity test. For submerged electric motor driven pumps, the capacity test is to be carried out with the design fluid or with a fluid below the minimum working temperature. For shaft driven deep well pumps, the capacity test may be carried out with water.

As an alternative to the above, the certification of a pump may be carried out subject to the following:

- The pump has been approved as required by IR5.13.1.3.1, and

- The manufacturer has a recognized quality system that has been assessed and certified by IRS subject to periodic audits, and

- The quality control plan contains a provision to subject each pump to a hydrostatic test of the pump body equal to 1.5 times the design pressure and a capacity test. The manufacturer is to maintain records of such tests.

5.13.2 System testing requirements

5.13.2.1 The requirements of this sub-section shall apply to piping inside and outside the cargo tanks.

5.13.2.2 After assembly, all cargo and process piping are to be subjected to a strength test with a suitable fluid. The test pressure is to be at least 1.5 times the design pressure (1.25 times the design pressure where the test fluid is compressible) for liquid lines and 1.5 times the maximum system working pressure (1.25 times the maximum system working pressure where the test fluid is compressible) for vapour lines. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the test may be conducted prior to installation on board the ship. Joints welded on board are to be tested to at least 1.5 times the design pressure.

5.13.2.3 After assembly on board, each cargo and process piping system are to be subjected to a leak test using air, or other suitable medium, to a pressure depending on the leak detection method applied.

5.13.2.4 In double wall gas-fuel piping systems, the outer pipe or duct is also to be pressure tested to show that it can withstand the expected maximum pressure at gas pipe rupture.

5.13.2.5 All piping systems, including valves, fittings and associated equipment for handling cargo or vapours, are to be tested under normal operating conditions not later than at the first loading operation, in accordance with recognized standards.

5.13.3 Emergency shutdown valves

The closing characteristics of emergency shutdown valves used in liquid cargo piping systems are to be tested to demonstrate compliance with 18.10.2.1.3. This testing may be carried out on board after installation.

Section 6

Materials of Construction and Quality Control

6.0 Goal

To identify the required properties, testing standards and stability of metallic and non-metallic materials and fabrication processes used in the construction of cargo containment and piping systems to ensure they serve the functions for which they have been selected, as required in Section 4 and 5.

6.1 Definitions

6.1.1 Where reference is made in this chapter to A, B, D, E, AH, DH, EH and FH hull structural steels, these steel grades are hull structural steels according to recognized standards.

6.1.2 A piece is the rolled product from a single slab or billet or from a single ingot, if this is rolled directly into plates, strips, sections or bars.

6.1.3 A batch is the number of items or pieces to be accepted or rejected together, on the basis of the tests to be carried out on a sampling basis. The size of a batch is given in the recognized standards.

6.1.4 Controlled rolling (CR) is a rolling procedure in which the final deformation is carried out in the normalizing temperature range, resulting in a material condition generally equivalent to that obtained by normalizing.

6.1.5 Thermo-mechanical controlled processing (TMCP) is a procedure that involves strict control of both the steel temperature and the rolling reduction. Unlike CR, the properties conferred by TMCP cannot be reproduced by subsequent normalizing or other heat treatment. The use of accelerated cooling on completion of TMCP may also be accepted, subject to approval by the Administration/ IRS. The same applies for the use of tempering after completion of TMCP.

6.1.6 Accelerated cooling (AcC) is a process that aims to improve mechanical properties by controlled cooling with rates higher than air cooling, immediately after the final TMCP operation. Direct quenching is excluded from accelerated cooling. The material properties conferred by TMCP and AcC cannot be reproduced by subsequent normalizing or other heat treatment.

6.2 Scope and general requirements

6.2.1 This section gives the requirements for metallic and non-metallic materials used in the construction of the cargo system. This includes requirements for joining processes, production process, personnel qualification, NDT and inspection and testing including production testing. The requirements for rolled materials, forgings and castings are given in 6.4 and tables 6.1, to 6.5. The requirements for weldments are given in 6.5, and the guidance for non-metallic materials is given in appendix 4 of IGC Code. A quality assurance/quality control programme is to be implemented to ensure that the requirements of 6.2 are complied with.

6.2.2 The manufacture, testing, inspection and documentation are to be in accordance with recognized standards and the specific requirements given in this Chapter.

6.2.3 Where post-weld heat treatment is specified or required, the properties of the base material are to be determined in the heat-treated condition, in accordance with the applicable table of this section, and the weld properties are to be determined in the heat treated condition in accordance with 6.5. In cases where a post-weld heat treatment is applied, the test requirements may be modified at the discretion of the Administration/ IRS.

6.3 General test requirements and specifications

6.3.1 Tensile test

6.3.1.1 Tensile testing is to be carried out in accordance with recognized standards.

6.3.1.2 Tensile strength, yield stress and elongation are to be to the satisfaction of the Administration/ IRS. For carbon-manganese steel and other materials with definitive yield points, consideration is to be given to the limitation of the yield to tensile ratio.

6.3.2 Toughness test

6.3.2.1 Acceptance tests for metallic materials are to include Charpy V-notch toughness tests, unless otherwise specified by the Administration. The specified Charpy V-notch requirements are minimum average energy values for three full size (10 [mm] × 10 [mm]) specimens and minimum single energy values for individual specimens. Dimensions and tolerances of Charpy V-notch specimens are to be in accordance with recognized standards. The testing and requirements for specimens smaller than 5 [mm] in size are to be in accordance with recognized standards. Minimum average values for subsized specimens are to be:

Charpy V-notch specimen size (mm)	Minimum average energy of three specimens
10 x 10	KV
10 x 7.5	5/6 KV
10 x 5	2/3 KV

Where:

KV = the energy values (J) specified in tables 6.1 to 6.4

Only one individual value may be below the specified average value, provided it is not less than 70% of that value.

6.3.2.2 For base metal, the largest size Charpy V-notch specimens possible for the material thickness shall be machined with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness and the length of the notch perpendicular to the surface as shown in Fig.6.1.

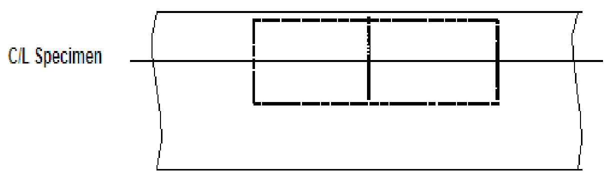


Fig.6.1 : Orientation of base metal test specimen

6.3.2.3 For a weld test specimen, the largest size Charpy V-notch specimens possible for the material thickness is to be machined, with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness. In all cases, the distance from the surface of the material to the edge of the specimen is to be approximately 1 [mm] or greater. In addition, for double-V butt welds, specimens are to be machined closer to the surface of the second welded section. The specimens are to be taken generally at each of the following locations, as shown in Fig.6.2, on the centreline of the welds, the fusion line and 1 [mm], 3 [mm] and 5 [mm]from the fusion line.

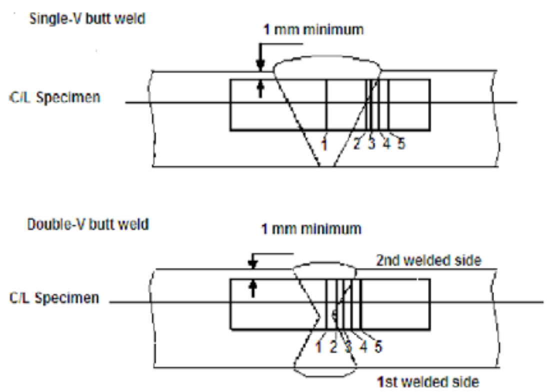


Fig.6.2 : Orientation of weld test specimen

Notch locations in Fig.6.2:

.1 Centreline of the weld.

.2 Fusion line.

.3 In heat-affected zone (HAZ), 1 [mm] from the fusion line.

.4 In HAZ, 3 [mm] from the fusion line.

.5 In HAZ, 5 [mm] from the fusion line.

6.3.2.4 If the average value of the three initial Charpy V-notch specimens fails to meet the stated requirements, or the value for more than one specimen is below the required average value, or when the value for one specimen is below the minimum value permitted for a single specimen, three additional specimens from the same material may be tested and the results be combined with those previously obtained to form a new average. If this new average complies with the requirements and if no more than two individual results are lower than the required average and no more than one result is lower than the required value for a single specimen, the piece or batch may be accepted.

6.3.3 Bend test

6.3.3.1 The bend test may be omitted as a material acceptance test, but is required for weld tests. Where a bend test is performed, this is to be done in accordance with recognized standards.

6.3.3.2 The bend tests are to be transverse bend tests, which may be face, root or side bends at the discretion of the Administration/ IRS. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels.

6.3.4 Section observation and other testing

Macrosection, microsection observations and hardness tests may also be required by the Administration/ IRS, and they are to be carried out in accordance with recognized standards, where required.

6.4 Requirements for metallic materials

6.4.1 General requirements for metallic materials

6.4.1.1 The requirements for materials of construction are shown in the tables as follows:

.1 Table 6.1: Plates, pipes (seamless and welded), sections and forgings for cargo tanks and process pressure vessels for design temperatures not lower than 0 [°C].

.2 Table 6.2: Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below 0 [°C] and down to -55 [°C].

.3 Table 6.3: Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below -55 [°C] and down to -165 [°C].

.4 Table 6.4: Pipes (seamless and welded), forgings and castings for cargo and process piping for design temperatures below 0 [°C] and down to -165 [°C].

.5 Table 6.5: Plates and sections for hull structures required by 4.19.1.2 and 4.19.1.3.

Table : 6.1		
PLATES, PIPES (SEAMLESS AND WELDED)[See note 1 and note 2], SECTIONS AND FORGING OFOR CARGO TANKS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES NOT LOWER THAN 0 ˚C		
CHEMICAL COMPOSITION AND HEAT TREATMENT		
• Carbon-manganese steel		
• Fully killed fine grain steel		
• Small additions of alloying elements by agreement with the Administration/ IRS		
• Composition limits to be approved by the Administration/ IRS		
• Normalized, or quenched and tempered [See note 4]		
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS		
Sampling Frequency		
• Plates	Each “piece” to be tested	
• Sections and forgings	Each “batch” to be tested	
Mechanical properties		
• Tensile properties	Specified minimum yield stress not to exceed 410 [N/mm^2] [See note 5]	
Toughness (Charpy V-notch test)		
• Plates	Transverse test pieces. Minimum average energy value (KV) 27J	
• Sections and forgings	Longitudinal test pieces. Minimum average energy (KV) 41J	
• Test temperature	Thickness t (mm)	Test temperature (˚C)
	t < 20	0
	20 < t ≤ 40 [See note 3]	-20

Notes

1 For seamless pipes and fittings normal practice applies. The use of longitudinally and spirally welded pipes is to be specially approved by the Administration or IRS. .

2 Charpy V-notch impact tests are not required for pipes.

Table 6.1 (Contd.)

3 This table is generally applicable for material thicknesses up to 40 mm. Proposals for greater thicknesses are to be approved by the Administration or IRS .

4 A controlled rolling procedure or TMCP may be used as an alternative.

5 Materials with specified minimum yield stress exceeding 410 [N/mm^2] may be approved by the Administration or IRS. For these materials, particular attention is to be given to the hardness of the welded and heat affected zones.

Table 6.2

PLATES, SECTIONS AND FORGINGS See note 1 **FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO -55 [°C]**
MAXIMUM THICKNESS 25 [mm] see note 2

CHEMICAL COMPOSITION AND HEAT TREATMENT

- Carbon-manganese steel
- Fully killed, aluminium treated fine grain steel
- Chemical composition (ladle analysis)

C	Mn	Si	S	P
0.16%max see note 3	0.7 – 1.60 %	0.1 – 0.50 %	0.025% max	0.025% max

Optional additions: Alloys and grain refining elements may be generally in accordance with the following:

Ni	Cr	Mo	Cu	Nb	V
0.8% max	0.25% max	0.08% max	0.35% max	0.05% max	0.1% max

Al content total 0.02% min (Acid soluble 0.015% min)

- Normalized, or quenched and tempered See note 4

TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS

Sampling frequency	
• Plates	Each “piece” to be tested
• Sections and forgings	Each “ batch” to be tested
Mechanical properties	
• Tensile properties	Specified minimum yield stress not to exceed 410 [N/mm^2] See note 5
Toughness (Charpy V-notch test)	
• Plates	Transverse test pieces. Minimum average energy value (KV) 27J
• Sections and forgings	Longitudinal test pieces. Minimum average energy (KV) 41J
• Test temperature	5 [˚C] below the design temperature or -20 [˚C], whichever is lower

Notes

1 The Charpy V-notch and chemistry requirements for forgings may be specially considered by the Administration/ IRS.

2 For material thickness of more than 25 mm, Charpy V-notch tests is to be conducted as follows:

Material Thickness [mm]	Test temperature [˚C]
25 < t ≤ 30	10 [˚C] below design temperature or -20[˚C], whichever is lower
30 < t ≤ 35	15 [˚C] below design temperature or -20[˚C], whichever is lower
35 < t ≤ 40	20 [˚C] below design temperature
40 < t	Temperature approved by Administration/ IRS

Table 6.2 (Contd.)

The impact energy value is to be in accordance with the table for the applicable type of test specimen.

Materials for tanks and parts of tanks which are completely thermally stress relieved after welding may be tested at a temperature 5 [°C] below design temperature or -20 [°C], whichever is lower.

For thermally stress relieved reinforcements and other fittings, the test temperature is to be the same as that required for the adjacent tank-shell thickness.

3 By special agreement with the Administration/ IRS, the carbon content may be increased to 0.18% maximum, provided the design temperature is not lower than -40 [°C].

4 A controlled rolling procedure or TMCP may be used as an alternative.

5 Materials with specified minimum yield stress exceeding 410 [N/mm^2] may be approved by Administration/IRS. For these materials, particular attention is to be given to the hardness of the welded and heat affected zones.

Guidance:
For materials exceeding 25 [mm] in thickness for which the test temperature is -60 [°C] or lower, the application of specially treated steels or steels in accordance with Table 6.3 may be necessary.

Table 6.3

PLATES, SECTIONS AND FORGINGS See note 1 FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW -55 [°C] AND DOWN TO -165 [°C] See note 2
MAXIMUM THICKNESS 25 [mm] see note 3 and note 4

Minimum design temperature [˚C]	Chemical composition See note 5 and heat treatment	Impact test temperature [˚C]
-60	1.5% nickel steel – normalized or normalized and tempered or quenched and tempered or TMCP See note 6	-65
-65	2.25% nickel steel – normalized or normalized and tempered or quenched and tempered or TMCP See note 6 and 7	-70
-90	3.5% nickel steel – normalized or normalized and tempered or quenched and tempered or TMCP See note 6 and 7	-95
-105	5% nickel steel – normalized or normalized and tempered or quenched and tempered See note 6,7and 8	-110
-165	9% nickel steel – double normalized and tempered or quenched and tempered See note 6	-196
-165	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347 solution treated See note 9	-196
-165	Aluminium alloys; such as type 5083 annealed	Not required
-165	Austenitic Fe-Ni alloy (36% nickel). Heat treatment as agreed.	Not required

TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS

Sampling frequency	
• Plates	Each “piece” to be tested
• Sections and forgings	Each “ batch” to be tested
Toughness (Charpy V-notch test)	
• Plates	Transverse test pieces. Minimum average energy value (KV) 27J
• Sections and forgings	Longitudinal test pieces. Minimum average energy (KV) 41J

Table 6.3 : Notes

1 The impact test required for forgings used in critical application is to be subject to special consideration by the Administration/ IRS.

2 The requirements for design temperatures below -165[°C] are to be specially agreed with the Administration/ IRS.

3 For materials 1.5% Ni, 2.25% Ni, 3.5% Ni and 5% Ni, with thicknesses greater than 25 [mm], the impact tests are to be conducted as follows:

Material Thickness [mm]	Test temperature [˚C]
25 < t ≤ 30	10 [˚C] below design temperature
30 < t ≤ 35	15 [˚C] below design temperature
35 < t ≤ 40	20 [˚C] below design temperature

The energy value is to be in accordance with the table for the applicable type of test specimen. For material thickness of more than 40 [mm], the Charpy V-notch values is to be specially considered.

4 For 9% Ni steels, austenitic stainless steels and aluminium alloys, thickness greater than 25 [mm] may be used.

5 The chemical composition limits are to be in accordance with recognized standards.

6 TMCP nickel steels will be subject to acceptance by the Administration/ IRS.

7 A lower minimum design temperature for quenched and tempered steels may be specially agreed with the Administration/ IRS.

8 A specially heat treated 5% nickel steel, for example triple heat treated 5% nickel steel, may be used down to -165 [°C], provided that the impact tests are carried out at -196 [°C].

9 The impact test may be omitted, subject to agreement with the Administration/ IRS.

Table 6.4

PIPES(SEAMLESS AND WELDED) [See note 1] , FORGINGS[See note 2], AND CASTINGS[See note 2] FOR CARGO AND PROCESS PIPING FOR DESIGN TEMPERATURES BELOW 0 [˚C] AND DOWN TO -165 [˚C][See note 3]
MAXIMUM THICKNESS 25 [mm]

Minimum design temperature [˚C]	Chemical composition [See note 5] and heat treatment	Impact test	
		Test temp [˚C]	Minimum average energy (KV)
-55	Carbon-manganese steel. Fully killed fine grain. Normalized or as agreed [See note 6]	See note 4	27
-65	2.25% nickel steel. Normalized, normalized and tempered or quenched and tempered [See note 6]	-70	34
-90	3.5% nickel steel. Normalized, normalized and tempered or quenched and tempered [See note 6]	-95	34
-165	9% nickel steel [See note 7]. Double Normalized, and tempered or quenched and tempered	-196	41
	Austenitic steels, such as types 304, 304L, 316, 316L, 321, and 347.Solution treated [See note 8]	-196	41
	Aluminium alloys; such as type 5083 annealed		Not required

Table 6.4 (Contd.)

TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS

Sampling frequency

- Each "batch" to be tested

Toughness (Charpy V-notch test)

- Impact test: Longitudinal test pieces

Notes

1 The use of longitudinally or spirally welded pipes is to be specially approved by the Administration/ IRS.

2 The requirements for forgings and castings may be subject to special consideration by the Administration/ IRS.

3 The requirements for design temperatures below -165 [°C] are to be specially agreed with the Administration/ IRS.

4 The test temperature is to be 5 [°C] below the design temperature or -20 [°C], whichever is lower.
5 The composition limits are to be in accordance with recognized standards.

6 A lower design temperature may be specially agreed with the Administration/ IRS for quenched and tempered materials.

7 This chemical composition is not suitable for castings.

8 Impact tests may be omitted, subject to agreement with the Administration/ IRS.

Table 6.5

PLATES AND ECTIONS FOR HULL STRUCTURES REQUIRED BY 4.19.1.2 AND 4.19.1.3

Minimum design temperature of hull structure (˚C)	**Maximum thickness (mm) for steel grades**							
	A	**B**	**D**	**E**	**AH**	**DH**	**EH**	**FH**
0 and above See note 1 **-5 and above** See note 2	**Recognized standards**							
down to -5	**15**	**25**	**30**	**50**	**25**	**45**	**50**	**50**
down to -10	**X**	**20**	**25**	**50**	**20**	**40**	**50**	**50**
down to -20	**X**	**X**	**20**	**50**	**X**	**30**	**50**	**50**
down to -30	**X**	**X**	**X**	**40**	**X**	**20**	**40**	**50**
Below -30	**In accordance with table 6.2, except that the thickness limination given in table 6.2 and in note 2 of that table does not apply.**							

Notes

" X " means steel grade not to used

1 for the purpose of 4.19.1.3

2 for the purpose of 4.19.1.2

6.5 Welding of metallic materials and non-destructive testing

6.5.1 General

6.5.1.1 This sub-section shall apply to primary and secondary barriers only, including the inner hull where this forms the secondary barrier. Acceptance testing is specified for carbon, carbon-manganese, nickel alloy and stainless steels, but these tests may be adapted for other materials. At the discretion of the Administration/ IRS, impact testing of stainless steel and aluminium alloy weldments may be omitted and other tests may be specially required for any material.

6.5.2 Welding Consumables

6.5.2.1 Consumables intended for welding of cargo tanks are to be in accordance with Recognized Standards. Deposited weld metal tests and butt weld tests would be required for all consumables. The results obtained from tensile and Charpy V-notch impact tests are to be in accordance with the Recognized Standards. The chemical composition of the deposited weld metal is to be recorded for information.

6.5.3 Welding procedure tests for cargo tanks and process pressure vessels

6.5.3.1 Welding Procedure tests for cargo tanks and process pressure vessels are required for all butt welds.

6.5.3.2 The test assemblies are to be representative of:

.1 Each base material

.2 Each type of consumable and welding process and,

.3 Each welding position.

6.5.3.3 For butt welds in plates, the test assemblies are to be so prepared that the rolling direction is parallel to the direction of welding. The range of thickness qualified by each welding procedure test is to be in accordance with Recognized Standards. Radiographic or ultrasonic testing may be performed at the option of the fabricator.

6.5.3.4 The following welding procedure tests for cargo tanks and process pressure vessels are to be carried out in accordance with 6.3, with specimens made from each test assembly:

.1 Cross-weld tensile tests.

.2 Longitudinal all-weld testing, where required by recognized standards.

.3 Transverse bend tests: These bend tests may be face, root or side bends. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels.

.4 One set of three Charpy V-notch impacts, generally at each of the following locations, as shown in Fig.6.2:

.1 centreline of the weld;

.2 fusion line;

.3 1 mm from the fusion line;

.4 3 mm from the fusion line; and

.5 5 mm from the fusion line; and

.5 macrosection, microsection and harness survey may also be required.

6.5.3.5 Each test is to satisfy the following requirements:

.1 **Tensile tests** : cross-weld tensile strength shall not be less than the specified minimum tensile strength for the appropriate parent materials. For aluminium alloys, reference shall be made to 4.18.1.3 with regard to the requirements for weld metal strength of under-matched welds (where the weld metal has a lower tensile strength than the parent metal). In every case, the position of fracture is to be recorded for information;

.2 **Bend tests** : No fracture is acceptable after a 180° bend over a former of a diameter four times the thickness of the test pieces, and

.3 **Charpy V-notch impact tests**: Charpy v-notch tests are to be conducted at the temperature prescribed for the base material being joined. The results of weld metal impact tests, minimum average energy (KV), are to be no less than 27J. The weld metal requirements for subsize specimens and single energy values are to be in accordance with 6.3.2 . The results of fusion line and heat affected zone impact tests are to show a minimum average energy (KV) in accordance with the transverse or longitudinal requirements of the base material, whichever is applicable, and for subsize specimens, the minimum average energy (KV) is to be in accordance with 6.3.2 . If the material thickness does not permit machining either full size or standard subsize specimens, the testing procedure and acceptance standards are to be in accordance with Recognized Standards.

6.5.3.6 Procedure tests for fillet welding are to be in accordance with recognized standards. In such cases, consumables are to be so selected that exhibit satisfactory impact properties.

6.5.4 Welding Procedure Tests for Piping

Welding procedure tests for piping are to be carried out and are to be similar to those detailed for cargo tanks in 6.5.3.

6.5.5 Production weld tests

6.5.5.1 For all cargo tanks and process pressure vessels except integral and membrane tanks, production weld tests are generally to be performed for approximately each 50 [m] of butt weld joints and are to be representative of each welding position. For secondary barriers, the same type production tests as required for primary tanks are to be performed except that the number of tests may be reduced subject to agreement with IRS. Tests, other than those specified in 6.5.5.2 to 6.5.5.5 , may be required for cargo tanks or secondary barriers.

6.5.5.2 The production tests for type A and type B independent tanks and semi-membrane tanks shall include bend tests and, where required for procedure tests, one set of three Charpy V-notch tests. The tests are to be made for each 50 [m] of weld. The Charpy V-notch tests are to be made with specimens having the notch alternately located in the centre of the weld and in the heat-affected zone (most critical location based on procedure qualification results). For austenitic stainless steel, all notches are to be in the centre of the weld.

6.5.5.3 For type C independent tanks and process pressure vessels, transverse weld tensile tests are required in addition to the tests listed in 6.5.5.2. Tensile tests are to meet the requirements of 6.5.3.5.

6.5.5.4 The quality assurance/quality control programme are to ensure the continued conformity of the production welds as defined in the material manufacturers quality manual.

6.5.5.5 The test requirements for integral and membrane tanks are the same as the applicable test requirements listed in 6.5.3.

6.5.6 Non-destructive testing

6.5.6.1 All test procedures and acceptance standards are to be in accordance with recognized standards, unless the designer specifies a higher standard in order to meet design assumptions. Radiographic testing is to be used, in principle, to detect internal defects. However, an approved ultrasonic test procedure in lieu of radiographic testing may be conducted, but, in addition, supplementary radiographic testing at selected locations is to be carried out to verify the results. Radiographic and ultrasonic testing records are to be retained.

6.5.6.2 For Type A independent tanks and semi-membrane tanks where the design temperature is below -20 [°C] , and for Type B independent tanks, regardless of temperature, all full penetration butt welds of the shell plating of cargo tanks are to be subjected to no-destructive testing suitable to detect internal defects over their full length. Ultrasonic testing in lieu of radiographic testing may be carried out under the same conditions as described in 6.5.6.1.

6.5.6.3 Where the design temperature is higher than -20 [°C], all full penetration butt welds in way of intersections and at least 10 per cent of the remaining full penetration welds of tank structures are to be subjected to radiographic testing or ultrasonic testing under the same condition as described in 6.5.6.1.

6.5.6.4 In each case the remaining tank structure including the welding of stiffeners and other fittings and attachments are to be examined by magnetic particle or dye penetrant methods as considered necessary.

6.5.6.5 For type C independent tanks, the extent of non-destructive testing is to be total or partial according to recognized standards, but the controls to be carried out are not to be less than the following:

.1 Total non-destructive testing referred to in 4.23.2.1.3:

Radiographic testing:

.1 all butt welds over their full length;

Non-destructive testing for surface crack detection:

.2 all welds over 10% of their length;

.3 reinforcement rings around holes, nozzles, etc., over their full length.

As an alternative, ultrasonic testing as described in 6.5.6.1 may be accepted as a partial substitute for the radiographic testing. In addition, the Administration/ IRS may require total ultrasonic testing on welding of reinforcement rings around holes, nozzles, etc.

.2 Partial non-destructive testing referred to in 4.23.2.1.3:

Radiographic testing:

.1 all butt-welded crossing joints and at least 10% of the full length of butt welds at selected positions uniformly distributed;
Non-destructive testing for surface crack detection:

Non-destructive testing for surface crack detection:

.2 reinforcement rings around holes, nozzles, etc., over their full length;

Ultrasonic testing:

.3 as may be required by the Administration/ IRS.

6.5.6.6 The quality assurance/quality control programme is to ensure the continued conformity of the non-destructive testing of welds, as defined in the material manufacturer's quality manual.

6.5.6.7 Inspection of piping is to be carried out in accordance with the requirements of Sec.5.

6.5.6.8 The secondary barrier is to be non-destructive tested for internal defects as considered necessary. Where the outer shell of the hull is part of the secondary barrier, all sheer strake butts and the intersections of all butts and seams in the side shell are to be tested by radiographic testing.

6.6 Other requirements for construction in metallic materials

6.6.1 **General**

6.6.1.1 Inspection and non-destructive testing of welds are to be in accordance with the requirements of 6.5.5 and 6.5.6. Where higher standards or tolerances are assumed in the design, they are also to be satisfied.

6.6.2 **Independent tank**

6.6.2.1 For type C tanks and type B tanks primarily constructed of bodies of revolution, the tolerances relating to manufacture, such as out-of-roundness, local deviations from the true form, welded joints alignment and tapering of plates having different thicknesses, are to comply with recognized standards. The tolerances are also to be related to the buckling analysis referred to in 4.22.3.2 and 4.23.3.2.

6.6.2.2 For type C tanks of carbon and carbon-manganese steel, post-weld heat treatment is to be performed after welding, if the design temperature is below -10 [°C]. Post-weld heat treatment in all other cases and for materials other than those mentioned above are to be to recognized standards. The soaking temperature and holding time are to be to the recognized standards.

6.6.2.3 In the case of type C tanks and large cargo pressure vessels of carbon or carbon-manganese steel, for which it is difficult to perform the heat treatment, mechanical stress relieving by pressurizing may be carried out as an alternative to the heat treatment and subject to the following conditions:

.1 complicated welded pressure vessel parts such as sumps or domes with nozzles, with adjacent shell plates are to be heat treated before they are welded to larger parts of the pressure vessel;

.2 the mechanical stress relieving process is to be preferably be carried out during the hydrostatic pressure test required by 4.23.6, by applying a higher pressure than the test pressure required by 4.23.6.1. The pressurizing medium is to be water;

.3 for the water temperature, 4.23.6.2 applies;

.4 stress relieving is to be performed while the tank is supported by its regular saddles or supporting structure or, when stress relieving cannot be carried out on board, in a manner which will give the same stresses and stress distribution as when supported by its regular saddles or supporting structure;

.5 the maximum stress relieving pressure is to be held for 2 h per 25 [mm] of thickness, but in no case less than 2 h;

.6 the upper limits placed on the calculated stress levels during stress relieving are to be the following:

.1 equivalent general primary membrane stress: 0.9 *Re*;

.2 equivalent stress composed of primary bending stress plus membrane stress: 1.35 *Re*, where *R*e is the specific lower minimum yield stress or 0.2% proof stress at test temperature of the steel used for the tank;

.7 strain measurements will normally be required to prove these limits for at least the first tank of a series of identical tanks built consecutively. The location of strain gauges is to be included in the mechanical stress relieving procedure to be submitted in accordance with 6.6.2.3;

.8 the test procedure is to demonstrate that a linear relationship between pressure and strain is achieved at the end of the stress relieving process when the pressure is raised again up to the design pressure;

.9 high-stress areas in way of geometrical discontinuities such as nozzles and other openings are to be checked for cracks by dye penetrant or magnetic particle inspection after mechanical stress relieving. Particular attention in this respect is to be paid to plates exceeding 30 [mm] in thickness;

.10 steels which have a ratio of yield stress to ultimate tensile strength greater than 0.8 are generally not to be mechanically stress relieved. If, however, the yield stress is raised by a method giving high ductility of the steel, slightly higher rates may be accepted upon consideration in each case;

.11 mechanical stress relieving cannot be substituted for heat treatment of cold formed parts of tanks, if the degree of cold forming exceeds the limit above which heat treatment is required;

.12 the thickness of the shell and heads of the tank are not to exceed 40 [mm]. Higher thicknesses may be accepted for parts which are thermally stress relieved;

.13 local buckling is to be guarded against, particularly when tori-spherical heads are used for tanks and domes; and

.14 the procedure for mechanical stress relieving is to be to a recognized standard.

6.6.3 Secondary barriers

During construction, the requirements for testing and inspection of secondary barriers are to be approved or accepted by IRS (see 4.6.2.5 and 4.6.2.6).

6.6.4 Semi-membrane tanks

For semi-membrane tanks, the relevant requirements in 6.6 for independent tanks or for membrane tanks are to be applied as appropriate.

6.6.5 Membrane tanks

The quality assurance/quality control programme are to ensure the continued conformity of the weld procedure qualification, design details, materials, construction, inspection and production testing of components. These standards and procedures are to be developed during the prototype testing programme.

6.7 Non-metallic materials

6.7.1 General

The information in the attached appendix 4 of IGC Code is given for guidance in the selection and use of these materials, based on the experience to date.

Section 7

Cargo Pressure/Temperature Control

7.0 Goal

To maintain the cargo tank pressure and temperature within design limits of the containment system and/or carriage requirements of the cargo.

7.1 Methods of control

7.1.1 With the exception of tanks designed to withstand full gauge vapour pressure of the cargo under conditions of the upper ambient design temperatures, cargo tanks' pressure and temperature is to be maintained at all times within their design range by either one, or a combination of, the following methods:

.1 reliquefaction of cargo vapours;

.2 thermal oxidation of vapours;

.3 pressure accumulation; and

.4 liquid cargo cooling.

7.1.2 For certain cargoes, where required by Sec 17, the cargo containment system is to be capable of withstanding the full vapour pressure of the cargo under conditions of the upper ambient design temperatures, irrespective of any system provided for dealing with boil-off gas.

7.1.3 Venting of the cargo to maintain cargo tank pressure and temperature is not acceptable except in emergency situations. The Administration may permit certain cargoes to be controlled by venting cargo vapours to the atmosphere at sea. This may also be permitted in port with the authorization of the port Administration.

7.2 Design of systems

For normal service, the upper ambient design temperature is to be:

- sea: 32 [°C]

- air: 45 [°C]

For service in particularly hot or cold zones, these design temperatures are to be increased or decreased, to the satisfaction of the Administration/ IRS. The overall capacity of the system is to be such that it can control the pressure within the design conditions without venting to atmosphere.

7.3 Reliquefaction of cargo vapours

7.3.1 General

The reliquefaction system may be arranged in one of the following ways:

.1 a direct system, where evaporated cargo is compressed, condensed and returned to the cargo tanks;

.2 an indirect system, where cargo or evaporated cargo is cooled or condensed by refrigerant without being compressed;

.3 a combined system, where evaporated cargo is compressed and condensed in a cargo/refrigerant heat exchanger and returned to the cargo tanks; and

.4 if the reliquefaction system produces a waste stream containing methane during pressure control operations within the design conditions, these waste gases, as far as reasonably practicable, are disposed of without venting to atmosphere.

Note:

The requirements of sec 17 and 19 may preclude the use of one or more of these systems or may specify the use of a particular system.

7.3.2 Compatibility

Refrigerants used for reliquefaction are to be compatible with the cargo they may come into contact with. In addition, when several refrigerants are used and may come into contact, they are to be compatible with each other.

7.4 Thermal oxidation of vapours

7.4.1 General

Maintaining the cargo tank pressure and temperature by means of thermal oxidation of cargo vapours, as defined in 1.2.52 and 16.2 are to be permitted only for LNG cargoes. In general:

.1 thermal oxidation systems shall exhibit no externally visible flame and shall maintain the uptake exhaust temperature below 535 [°C];

.2 arrangement of spaces where oxidation systems are located are to comply with 16.3 and supply systems shall comply with 16.4; and

.3 if waste gases coming from any other system are to be burnt, the oxidation system is to be designed to accommodate all anticipated feed gas compositions.

7.4.2 Thermal oxidation systems

Thermal oxidation systems are to comply with the following:

.1 each thermal oxidation system are to have a separate uptake;

.2 each thermal oxidation system are to have a dedicated forced draught system; and

.3 combustion chambers and uptakes of thermal oxidation systems are to be designed to prevent any accumulation of gas.

7.4.3 Burners

Burners are to be designed to maintain stable combustion under all design firing conditions.

7.4.4 Safety

7.4.4.1 Suitable devices are to be installed and arranged to ensure that gas flow to the burner is cut off unless satisfactory ignition has been established and maintained.

7.4.4.2 Each oxidation system is to have provision to manually isolate its gas fuel supply from a safely accessible position.

7.4.4.3 Provision are to be made for automatic purging the gas supply piping to the burners by means of an inert gas, after the extinguishing of these burners.

7.4.4.4 In case of flame failure of all operating burners for gas or oil or for a combination thereof, the combustion chambers of the oxidation system are to be automatically purged before relighting.

7.4.4.5 Arrangements are to be made to enable the combustion chamber to be manually purged.

7.5 Pressure accumulation systems

The containment system insulation, design pressure or both are to be adequate to provide for a suitable margin for the operating time and temperatures involved. No additional pressure and temperature control system is required. Conditions for acceptance are to be recorded in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required in 1.4.4.

7.6 Liquid cargo cooling

The bulk cargo liquid may be refrigerated by coolant circulated through coils fitted either inside the cargo tank or onto the external surface of the cargo tank.

7.7 Segregation

Where two or more cargoes that may react chemically in a dangerous manner are carried simultaneously, separate systems as defined in 1.2.47, each complying with availability criteria as specified in 7.8, is to be provided for each cargo. For simultaneous carriage of two or more cargoes that are not reactive to each other but where, due to properties of their vapour, separate systems are necessary, separation may be by means of isolation valves.

7.8 Availability

The availability of the system and its supporting auxiliary services are to be such that:

.1 in case of a single failure of a mechanical non-static component or a component of the control systems, the cargo tanks' pressure and temperature can be maintained within their design range without affecting other essential services;

.2 redundant piping systems are not required;

.3 heat exchangers that are solely necessary for maintaining the pressure and temperature of the cargo tanks within their design ranges are to have a standby heat exchanger, unless they have a capacity in excess of 25% of the largest required capacity for pressure control and they can be repaired on board without external resources. Where an additional and separate method of cargo tank pressure and temperature control is fitted that is not reliant on the sole heat exchanger, then a standby heat exchanger is not required; and

.4 for any cargo heating or cooling medium, provisions are to be made to detect the leakage of toxic or flammable vapours into an otherwise non-hazardous area or overboard in accordance with 13.6. Any vent outlet from this leak detection arrangement shall be to a safe location and be fitted with a flame screen.

Section 8

Vent systems for cargo containment

8.0 Goal

To protect cargo containment systems from harmful overpressure or underpressure at all times.

8.1 General

8.1.1 All cargo tanks are to be provided with a pressure relief system appropriate to the design of the cargo containment system and the cargo being carried. Hold spaces, interbarrier spaces and cargo piping which may be subject to pressures beyond their design capabilities are also to be provided with a suitable pressure relief system. Pressure control systems specified in Sec.7 are to be independent of the pressure relief systems.

8.2 Pressure relief systems

8.2.1 Cargo tanks, including deck tanks, are to be fitted with a minimum of two pressure relief valves (PRVs), each being of equal size within manufacturer's tolerances and suitably designed and constructed for the prescribed service.

8.2.2 Interbarrier spaces are to be provided with pressure relief devices complying with recognized standards.

8.2.3 The setting of the pressure relief valves are not to be higher than the vapour pressure which has been used in the design of the tank. Where two or more pressure relief valves are fitted, valves comprising not more than 50% of the total relieving capacity may be set at a pressure up to 5% above MARVS to allow sequential lifting, minimizing unnecessary release of vapour.

8.2.4 The following temperature requirements apply to PRVs fitted to pressure relief systems:

.1 PRVs on cargo tanks with a design temperature below 0 [^{o}C] are to be designed and arranged to prevent their becoming inoperative due to ice formation;

.2 the effects of ice formation due to ambient temperatures are to be considered in the construction and arrangement of PRVs;

.3 PRVs are to be constructed of materials with a melting point above 925 [°C]. Lower melting point materials for internal parts and seals may be accepted, provided that fail-safe operation of the PRV is not compromised; and

.4 sensing and exhaust lines on pilot operated relief valves are to be of suitably robust construction to prevent damage.

8.2.5 Valve testing

8.2.5.1 PRVs are to be type-tested. Type tests are to include:

.1 verification of relieving capacity;

.2 cryogenic testing when operating at design temperatures colder than -55 [°C];

.3 seat tightness testing; and

.4 pressure containing parts are pressure tested to at least 1.5 times the design pressure.

PRVs are to be tested in accordance with recognized standards (such as ISO 21013-1:2008 – Cryogenic vessels – Pressure-relief accessories for cryogenic service – part 1: Recloseable pressure-relief valves; and ISO 4126-1; 2004 Safety devices for protection against excessive pressure – part 1 and part 4: Safety valves.)

8.2.5.2 Each PRV is to be tested to ensure that:

.1 it opens at the prescribed pressure setting, with an allowance not exceeding ± 10% for 0 to 0.15 [MPa], ± 6% for 0.15 to 0.3 [MPa], ± 3% for 0.3 [MPa] and above;

.2 seat tightness is acceptable; and

.3 pressure containing parts will withstand at least 1.5 times the design pressure.

8.2.6 PRVs are to be set and sealed by IRS, and a record of this action, including the valves' set pressure, is to be retained on board the ship.

8.2.7 Cargo tanks may be permitted to have more than one relief valve set pressure in the following cases :

.1 installing two or more properly set and sealed PRVs and providing means as necessary for isolating the valves not in use from the cargo tank; or

.2 installing relief valves whose settings may be changed by the use of a previously approved device not requiring pressure testing to verify the new set pressure. All other valve adjustments are to be sealed.

8.2.8 Changing the set pressure under the provisions of 8.2.7 and the corresponding resetting of the alarms referred to in 13.4.2 are to be carried out under the supervision of the master in accordance with approved procedures and as specified in the ship's operating manual. Changes in set pressure are to be recorded in the ship's log and a sign is to be posted in the cargo control room, if provided, and at each relief valve, stating the set pressure.

8.2.9 In the event of a failure of a cargo tank-installed PRV, a safe means of emergency isolation is to be available:

.1 Procedures are to be provided and included in the cargo operations manual (see 18.2).

.2 The procedures are to allow only one of the cargo tank installed PRVs to be isolated.

.3 Isolation of the PRV is to be carried out under the supervision of the master. This action is to be recorded in the ship's log and a sign posted in the cargo control room, if provided, and at the PRV.

.4 The tank is not to be loaded until the full relieving capacity is restored.

8.2.10 Each PRV installed on a cargo tank is to be connected to a venting system, which is to be:

.1 so constructed that the discharge will be unimpeded and directed vertically upwards at the exit;

.2 arranged to minimize the possibility of water or snow entering the vent system;

.3 arranged such that the height of vent exits are not to be less than B/3 or 6 [m,] whichever is the greater, above the weather deck; and

.4 6 [m] above working areas and walkways.

8.2.11.1 Cargo PRV vent exits are to be arranged at a distance at least equal to B or 25 [m], whichever is less, from the nearest air intake, outlet or opening to accommodation spaces, service spaces and control stations, or other non-hazardous areas . For ships less than 90 [m] in length, smaller distances may be permitted.

8.2.11.2 All other vent outlets connected to the cargo containment system are to be arranged at a distance of at least 10 [m] from the nearest air intake, outlet or opening to accommodation spaces, service spaces and control stations, or other non-hazardous areas.

8.2.12 All other cargo vent exits not dealt with in other Sections are to be arranged in accordance with 8.2.10, 8.2.11.1 and 8.2.11.2.Means are to be provided to prevent liquid overflow from vent mast outlets, due to hydrostatic pressure from spaces to which they are connected.

8.2.13 If cargoes that react in a dangerous manner with each other are carried simultaneously, a separate pressure relief system is to be fitted for each one.

8.2.14 In the vent piping system, means for draining liquid from places where it may accumulate is to be provided. The PRVs and piping are to be arranged so that liquid can, under no circumstances, accumulate in or near the PRVs.

8.2.15 Suitable protection screens of not more than 13 [mm] square mesh are to be fitted on vent outlets to prevent the ingress of extraneous objects without adversely affecting the flow. Other requirements for protection screens apply when carrying specific cargoes (see 17.9 and 17.21).

8.2.16 All vent piping are to be designed and arranged not to be damaged by the temperature variations to which it may be exposed, forces due to flow or the ship's motions.

8.2.17 PRVs are to be connected to the highest part of the cargo tank above deck level. PRVs are to positioned on the cargo tank so that they will remain in the vapour phase at the filling limit (FL) as defined in chapter 15, under conditions of 15° list and 0.015L trim, where L is as defined in 1.2.31.

8.2.18 The adequacy of the vent system fitted on tanks loaded in accordance with 15.5.2 is to be demonstrated , taking into account the recommendation developed by IMO (Guidelines for the evaluation of the adequacy of type C tank vent systems - IMO Res.A.829(19)). A relevant certificate is to be permanently kept on board the ship. For the purposes of this paragraph, vent system means:

a) the tank outlet and the piping to the pressure relief valve;

b) the pressure relief valve;

c) the piping from the pressure relief valve to the location of discharge to the atmosphere and including any interconnections and piping that joins other tanks.

8.3 Vacuum protection systems

8.3.1 Cargo tanks not designed to withstand a maximum external pressure differential 0.025 [MPa] (0.25 [bar]), or tanks that cannot withstand the maximum external pressure differential that can be attained at maximum discharge rates with no vapour return into the cargo tanks, or by operation of a cargo refrigeration system, or by thermal oxidation , are to be fitted with:

.1 two independent pressure switches to sequentially alarm and subsequently stop all suction of cargo liquid or vapour from the cargo tank, and refrigeration equipment if fitted, by suitable means at a pressure sufficiently below the maximum external designed pressure differential of the cargo tank; or

.2 vacuum relief valves with a gas flow capacity at least equal to the maximum cargo discharge rate per cargo tank, set to open at a pressure sufficiently below the external design differential pressure of the cargo tank;

8.3.2 Subject to the requirements of Sec.17, the vacuum relief valves are to admit an inert gas, cargo vapour or air to the cargo tank and are to be arranged to minimize the possibility of the entrance of water or snow. If cargo vapour is admitted, it is to be from a source other than the cargo vapour lines.

8.3.3 The vacuum protection system is to be capable of being tested to ensure that it operates at the prescribed pressure.

8.4 Sizing of pressure relieving system

8.4.1 Sizing of pressure relief valves

PRVs are to have a combined relieving capacity for each cargo tank to discharge the greater of the following with not more than a 20 per cent rise in cargo tank pressure above the MARVS:

8.4.1.1 The maximum capacity of the cargo tank inerting system if the maximum attainable working pressure of the cargo tank inerting system exceeds the MARVS of the cargo tanks; or

8.4.1.2 Vapours generated under fire exposure computed using the following formula:

$$Q = FGA^{0.82} \text{ [m}^3\text{/s]}$$

where,

Q = minimum required rate of discharge of air at standard conditions of 273.15 K and 0.1013 [MPa] (1.013 [bar]);

F = fire exposure factor for different cargo tank types;

F = 1.0 for tanks without insulation located on deck;

F = 0.5 for tanks above the deck when insulation is approved by Administration / IRS .(Approval will be based on the use of a fireproofing material, the thermal conductance of insulation, and its stability under fire exposure);

F = 0.5 for uninsulated independent tanks installed in holds;

F = 0.2 for insulated independent tanks in holds (or uninsulated independent tanks in insulated holds);

F = 0.1 for insulated independent tanks in inerted holds (or uninsulated independent tanks in inerted, insulated holds);

F = 0.1 for membrane and semi-membrane tanks.

For independent tanks partly protruding through the open deck, the fire exposure factor is to be determined on the basis of the surface areas above and below deck.

G = Gas factor

$$G = \frac{12.4}{L\,D}\sqrt{\frac{ZT}{M}}$$

with:

T = temperature in kelvins (K) at relieving conditions, i.e. 120 per cent of the pressure at which the pressure relief valve is set;

L = latent heat of the material being vaporized at relieving conditions, in [kJ/kg];

D = constant based on relation of specific heats k, and is calculated as follows:

$$D = \sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

Where:

k = ratio of specific heats at relieving conditions and the valve of which is between 1 and 2.2 . If k is not known, D=0.606 is to be used.

Z = compressibility factor of the gas at relieving conditions; if not known, Z = 1.0 should be used;

M = molecular mass of the product;

The gas factor of each cargo to be carried is to be determined and the highest value is to be used for PRV sizing.

A = external surface area of the tank [m^2] as defined in 1.2.14, for different tank types, as shown in Fig.8.1

8.4.1.3 The required mass flow of air at relieving conditions is given by the formula:

$$M_{air} = Q\,\rho_{\text{air}} \quad \text{[Kg/s]},$$

where:

density of air (ρ_{air}) = 1.293 [Kg/m^3] (air at 273.15 [K], 0.1013 [MPa]).

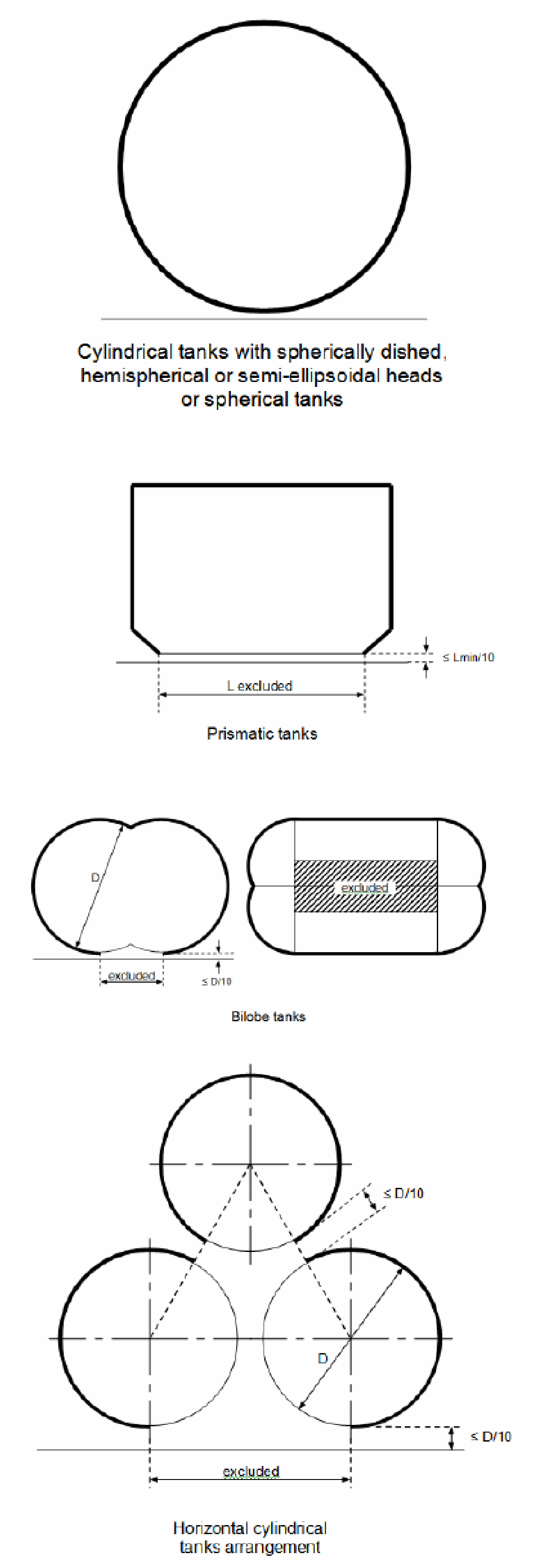

Cylindrical tanks with spherically dished,
hemispherical or semi-ellipsoidal heads
or spherical tanks
≤ Lmin/10
L excluded
Prismatic tanks
D
excluded
≤ D/10
excluded
Bilobe tanks
≤ D/10
D
≤ D/10
excluded
Horizontal cylindrical
tanks arrangement

Figure 8.1

8.4.2 Sizing of vent pipe system

Pressure losses upstream and downstream of the PRVs are to be taken into account when determining their size to ensure the flow capacity required by 8.4.1.

8.4.3 Upstream pressure losses

8.4.3.1 The pressure drop in the vent line from the tank to the PRV inlet is not to exceed 3% of the valve set pressure at the calculated flow rate, in accordance with 8.4.1.

8.4.3.2 Pilot-operated PRVs are to be unaffected by inlet pipe pressure losses when the pilot senses directly from the tank dome.

8.4.3.3 Pressure losses in remotely sensed pilot lines are to be considered for flowing type pilots.

8.4.4 Downstream pressure losses

8.4.4.1 Where common vent headers and vent masts are fitted, calculations are to include flow from all attached PRVs.

8.4.4.2 The built-up back pressure in the vent piping from the PRV outlet to the location of discharge to the atmosphere, and including any vent pipe interconnections that join other tanks, are not to exceed the following values:

.1 for unbalanced PRVs: 10% of MARVS;

.2 for balanced PRVs: 30% of MARVS; and

.3 for pilot operated PRVs: 50% of MARVS.

Alternative values provided by the PRV manufacturer may be accepted.

8.4.5 To ensure stable PRV operation, the blow-down is not to be less than the sum of the inlet pressure loss and 0.02 MARVS at the rated capacity.

Section 9

Cargo containment system atmosphere control

9.0 Goal

To enable monitoring of the integrity of the containment system and to ensure that the atmosphere within the system and hold spaces is maintained in a safe condition at all times that the ship is in service.

9.1 Atmosphere control within the cargo containment system

9.1.1 A piping system is to be arranged to enable each cargo tank to be safely gas-freed, and to be safely filled with cargo vapour from a gas-free condition. The system is to be arranged to minimize the possibility of pockets of gas or air remaining after changing the atmosphere.

9.1.2 For flammable cargoes, the system is to be designed to eliminate the possibility of a flammable mixture existing in the cargo tank during any part of the atmosphere change operation by utilizing an inerting medium as an intermediate step.

9.1.3 Piping systems that may contain flammable cargoes is to comply with 9.1.1 and 9.1.2.

9.1.4 A sufficient number of gas sampling points are to be provided for each cargo tank and cargo piping system to adequately monitor the process of atmosphere change. Gas sampling connections are to be fitted with a single valve above the main deck, sealed with a suitable cap or blank. (See also 5.6.5.5)

9.1.5 Inert gas utilized in these procedures may be provided from the shore or from the ship.

9.2 Atmosphere control within the hold spaces (cargo containment systems other than Type C independent tanks)

9.2.1 Interbarrier and hold spaces associated with cargo containment systems for flammable gases requiring full or partial secondary barriers are to be inerted with a suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system, or by shipboard storage, which is to be sufficient for normal consumption for at least thirty days.

9.2.2 Alternatively, subject to the restrictions specified in Sec.17, the spaces referred to in 9.2.1 requiring only a partial secondary barrier may be filled with dry air provided that the ship maintains a stored charge of inert gas or is fitted with an inert gas generation system sufficient to inert the largest of these spaces and provided that the configuration of the spaces and the relevant vapour detection systems, together with the capability of the inerting arrangements, ensure that any leakage from the cargo tanks will be rapidly detected and inerting effected before a dangerous condition can develop. Equipment for the provision of sufficient dry air of suitable quality to satisfy the expected demand is to be provided.

9.2.3 For non-flammable gases, the spaces referred to in 9.2.1 and 9.2.2 may be maintained with a suitable dry air or inert atmosphere.

9.3 Environmental control of spaces surrounding Type C independent tanks

Spaces surrounding cargo tanks that do not have secondary barriers are to be filled with suitable dry inert gas or dry air and be maintained in this condition with make-up inert gas provided by a shipboard inert gas generation system, shipboard storage of inert gas, or with dry air provided by suitable air drying equipment. If the cargo is carried at ambient temperature, the requirement for dry sir or inert gas is not applicable.

9.4 Inerting

9.4.1 Inerting refers to the process of providing a non-combustible environment. Inert gases are to be compatible chemically and operationally, at all temperatures likely to occur within the spaces and the cargo. The dew points of the gases are to be taken into consideration.

9.4.2 Where inert gas is also stored for fire-fighting purposes, it is to be carried in separate containers and is not to be used for cargo services.

9.4.3 Where inert gas is stored at temperature below 0 [°C], either as a liquid or as a vapour, the storage and supply system is to be designed so that the temperature of the ship's structure is not reduced below the limiting values imposed on it.

9.4.4 Arrangements to prevent the back flow of cargo vapour into the inert gas system that are suitable for the cargo carried, are to be provided. If such plants are located in machinery spaces or other spaces outside the cargo area, two non-return valves or equivalent devices and, in addition, a removable spool piece is to be fitted in the inert gas main in the cargo area. When not in use, the inert gas system is to be made separate from the cargo system in the cargo area except for connections to hold spaces or interbarrier spaces.

9.4.5 The arrangements are to be such that each space being inerted can be isolated and the necessary controls and relief valves etc. are to be provided for controlling pressure in these spaces.

9.4.6 Where insulation spaces are continually supplied with an inert gas as part of a leak detection system, means are to be provided to monitor the quantity of gas being supplied to individual spaces.

9.5 Inert gas production on board

9.5.1 The equipment is to be capable of producing inert gas with an oxygen content at no time greater than 5 per cent by volume subject to the Special Requirements of Sec.17. A continuous-reading oxygen content meter is to be fitted to the inert gas supply from the equipment and is to be fitted with an alarm set at a maximum of 5 per cent oxygen content by volume subject to the requirements of Sec.17.

9.5.2 An inert gas system is to have pressure controls and monitoring arrangements appropriate to the cargo containment system.

9.5.3 Spaces containing inert gas generation plants are to have no direct access to accommodation spaces, service spaces or control stations, but may be located in machinery spaces. Inert gas piping is not to pass through accommodation spaces, service spaces or control stations.

9.5.4 Combustion equipment for generating inert gas is not to be located within the cargo area. Special consideration may be given to the location of inert gas generating equipment using the catalytic combustion process.

Section 10

Electrical Installations

10.0 Goal

To ensure that electrical installations are designed such as to minimize the risk of fire and explosion from flammable products, and that electrical generation and distribution systems relating to the safe carriage, handling and conditioning of cargo liquid and vapour are available.

10.1 Definitions

For the purpose of this section, unless expressly provided otherwise, the definitions below shall apply.

10.1.1 *Hazardous area* is an area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

10.1.1.1 *Zone 0 hazardous area* is an area in which an explosive gas atmosphere is present continuously or is present for long periods.

10.1.1.2 *Zone 1 hazardous area* is an area in which an explosive gas atmosphere is likely to occur in normal operation.

10.1.1.3 *Zone 2 hazardous area* is an area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so infrequently and for a short period only.

10.1.2 *Non-hazardous area* is an area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

10.2 General requirements

IR 10.2.1 The provisions of this Section are applicable to ships carrying flammable products and are in addition to the requirements of Pt.4, Ch.8 of the Rules.

10.2.1 Electrical installations are to be such as to minimize the risk of fire and explosion from flammable products.

10.2.2 Electrical installations are to in accordance with recognized standards (such as IEC 60092-502:1999).

10.2.3 Electrical equipment and/or wiring is not to be installed in hazardous areas, unless essential for operational purposes or safety enhancement.

10.2.4 Where electrical equipment is installed in hazardous areas as provided in 10.2.3, it is to be selected, installed and maintained in accordance with standards not inferior to those acceptable to the IMO. Equipment for hazardous areas is to be evaluated and certified or listed by an accredited testing authority or notified body recognized by the Administration. Automatic isolation of non-certified equipment on detection of a flammable gas is not to be accepted as an alternative to the use of certified equipment.

10.2.5 To facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones in accordance with recognized standards.

10.2.6 Electrical generation and distribution systems, and associated control systems are to be designed such that a single fault will not result in the loss of ability to maintain cargo tank pressures, as required by 7.8.1, and hull structure temperature, as required by 4.19.1.6, within normal operating limits. Failure modes and effects are to be analysed and documented to a standard not inferior to those acceptable to the Administration/ IRS (such as IEC 60812, edition 2.0 2006-01 “Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)”).

10.2.7 The lighting system in hazardous areas is to be divided between at least two branch circuits. All switches and protective devices are to interrupt all poles or phases and are to be located in a non-hazardous area.

10.2.8 Electrical depth sounding or log devices and impressed current cathodic protection system anodes or electrodes are to be housed in gastight enclosures.

10.2.9 Submerged cargo pump motors and their supply cables may be fitted in cargo containment systems. Arrangements are to be made to automatically shut down the motors in the event of low-liquid level. This may be accomplished by sensing low pump discharge pressure, low motor current or low liquid level. This shutdown is to be alarmed at the cargo control station. Cargo pump motors are to be capable of being isolated from their electrical supply during gas-freeing operations.

Section 11

Fire Protection and Extinction

11.0 Goal

To ensure that suitable systems are provided to protect the ship and crew from fire in the cargo area.

11.1 Fire safety requirements

11.1.1 The requirements for tankers in Chapter II-2 of SOLAS are to apply to ships covered by this Chapter, irrespective of the tonnage including ships of less than 500 tons gross tonnage, except that:

.1 regulation 4.5.1.6 and 4.5.10 (Rules Pt.6, Ch.2, Cl.1.5.1.6 and Cl.1.5.10.1) does not apply;

.2 regulations 10.4 and 10.5 (Rules Pt.6, Ch.3, Cl.4.4 and Cl.4.5) are to apply as they would apply to tankers of 2000 tons gross and over;

.3 regulation 10.5.6 (Rules Pt.6, Ch.3, Cl.4.5.6) is to apply to ships of 2000 gross tonnage and over.

.4 the following regulations of Chapter II-2 of SOLAS related to tankers do not apply and are replaced by clauses/sections of this Chapter as under -

Regulation/(Rules)	Replaced by
10.10 (Pt.6, Cl.3, Cl.4.10)	11.6
4.5.1.1 and 4.5.1.2 (Pt.6, Ch.2, Cl.1.5.1.1 and Cl.1.5.1.2)	Sec.3
4.5.5 and 10.8 (Pt.6, Ch.2, Cl.1.5.5 and Pt.6, Ch.3, Cl.4.8)	Relevant Sections in this chapter 11.3 and 11.4
10.9 (Pt.6, Ch.3, Cl4.9)	11.5
10.2	11.2.1 to 11.2.4

.5 regulations 13.3.4 and 13.4.3 shall apply to ships of 500 gross tonnage and over.

11.1.2 All sources of ignition are to be excluded from spaces where flammable vapour may be present except otherwise provided in Secs. 10 and 16.

11.1.3 The provisions of the Section apply in conjunction with Sec.3.

11.1.4 For the purpose of fire fighting, any open deck areas above cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forward most hold space are to be included in the cargo area.

11.2 Fire mains and hydrants

11.2.1 Irrespective of size, ships carrying products that are subject to this chapter are to comply with requirements of regulations II-2/10.2 (Rules Pt.6, Ch.3, Cl.4.2) of the SOLAS convention, as applicable to the cargo ships, except that the required fire pump capacity and fire main and water service pipe diameter is not to be limited by the provisions of regulations II-2/10.2.2.4.1 and II-2/10.2.1.3 (Rules Pt.6, Ch.3, Cl.4.2.2.4.1 and Cl.4.2.1.3), when a fire pump is used to supply the water spray system as permitted by 11.3.3. The capacity of this fire pump is to be such that these areas can be protected when simultaneously supplying two jets of water from fire hoses with 19 [mm] nozzles at a pressure of at least 0.5 [MPa] gauge.

11.2.2 The arrangements are to be such that at least two jets of water can reach any part of the deck in the cargo area and those portions of the cargo containment system and tank covers that are above the deck. The necessary number of fire hydrants are to be located to satisfy the above arrangements and to comply with the requirements of Regulations II-2/10.2.1.5.1 and II-2/10.2.3.3 (Rules Pt.6, Ch.3, Cl.4.2.3.3) of

SOLAS with hose lengths as specified in II-2/10.2.3.1.1 (Rules Pt.6, Ch.3, Cl.4.2.3.1.1).In addition, the requirements of regulation II-2/10.2.1.6 (Rules Pt6, Ch 3, Cl 4.2.1.6) of SOLAS is to be meet at a pressure of at least 0.5 [MPa] gauge.

11.2.3 Stop valves are to be fitted in any cross-over provided and in the fire main(s) in a protected location before entering the cargo area and at intervals ensuring isolation of any damaged single section of the fire main, so that 11.2.2 can be complied with using not more than two lengths of hoses from the nearest fire hydrant. The water supply to the fire main serving the cargo area is to be a ring main supplied by the main fire pumps or a single main supplied by fire pumps positioned fore and aft of the cargo area, one of which is to be independently driven.

11.2.4 Nozzles are to be of an approved dual-purpose type (i.e spray/jet type) incorporating a shutoff.

11.2.5 After installation, the pipes, valves, fittings and assembled system are to be subject to a tightness and function test.

11.3 Water spray system

11.3.1 On ships carrying flammable and/or toxic products, a water spray system for cooling, fire prevention and crew protection is to be installed to cover:

.1 exposed cargo tank domes, any exposed parts of cargo tanks and any part of cargo tank covers that may be exposed to heat from fires in adjacent equipment containing cargo such as exposed booster pumps/heaters/re-gasification or re-liquefaction plants, hereafter addressed as gas process units, positioned on weather decks;

.2 exposed on-deck storage vessels for flammable or toxic products;

.3 gas process units positioned on deck;

.4 cargo liquid and vapour discharge and loading connections, including the presentation flange and the area where their control valves are situated, which are to be at least equal to the area of the drip trays provided;

.5 all exposed emergency shut-down (ESD) valves in the cargo liquid and vapour pipes, including the master valve for supply to gas consumers;

.6 exposed boundaries facing the cargo area, such as bulkheads of superstructures and deckhouses normally manned, cargo machinery spaces, store-rooms containing high fire-risk items and cargo control rooms. Exposed horizontal boundaries of these areas do not require protection unless detachable cargo piping connections are arranged above or below. Boundaries of unmanned forecastle structures not containing high fire risk items or equipment do not require water spray protection.

.7 exposed lifeboats, liferafts and muster stations facing the cargo area, regardless of distance to cargo area; and

.8 any semi-enclosed cargo machinery spaces and semi-enclosed cargo motor room.

Ships intended for operation as listed in 1.1.10 are to be subject to special consideration (see 11.3.3.2).

11.3.2.1 The system is to be capable of covering all areas mentioned in 11.3.1.1 to 11.3.1.8, with a uniformly distributed water application rate of at least 10 [l/m^2] per minute for the largest projected horizontal surfaces and 4 [l/m^2] per minute for vertical surfaces. For structures having no clearly defined horizontal or vertical surfaces, the capacity of the water-spray system is not to be less than the projected horizontal surface multiplied by 10 [l/m^2] per minute.

11.3.2.2 On vertical surfaces, spacing of nozzles protecting lower areas may take account of anticipated rundown from higher areas. Stop valves are to be fitted in the main supply lines(s) in the water spray system, at intervals not exceeding 40 [m], for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections which may be operated independently provided the necessary controls are located together in the readily accessible locations outside the cargo areas. A section protecting any area included in 11.3.1.1 and .2 is to cover at least the entire athwartship tank grouping in that area. Any gas process unit(s) included in 11.3.1.3 may be served by an independent section.

11.3.3 The capacity of the water spray pumps is to be capable of simultaneous protection of the greater of the following:

.1 any two complete athwartship tank groupings, including any gas process units within these areas; or

.2 for ships intended for operation as listed in 1.1.10, necessary protection subject to special consideration under 11.3.1 of any added fire hazard and the adjacent athwartship tank grouping,

in addition to the surfaces specified in 11.3.1.4 to 11.3.1.8. Alternatively, the main fire pumps may be used for this service provided that their total capacity is increased by the amount needed for the water spray system. In either case, a connection, through a stop valve, is to be made between the fire main and water spray system main supply line outside the cargo area.

11.3.4 The boundaries of superstructures and deckhouses normally manned, and lifeboats, liferafts and muster areas facing the cargo area, shall also be capable of being served by one of the fire pumps or the emergency fire pump, if a fire in one compartment could disable both fire pumps.

11.3.5 Water pumps normally used for other services may be arranged to supply the water-spray system main supply line.

11.3.6 All pipes, valves, nozzles and other fittings in the water-spray system are to be resistant to corrosion by seawater. Piping, fittings and related components within the cargo area (except gaskets) are to be designed to withstand 925 [°C]. The water-spray system is to be arranged with in-line filters to prevent blockage of pipes and nozzles. In addition, means are to be provided to back-flush the system with fresh water.

11.3.7 Remote starting of pumps supplying the water-spray system and remote operation of any normally closed valves in the system is to be arranged in suitable locations outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the protected areas.

11.3.8 After installation, the pipes, valves, fittings and assembled system are to be subject to a tightness and function test.

11.4 Dry chemical powder fire extinguishing systems

11.4.1 Ships in which carriage of flammable products is intended are to be fitted with fixed dry chemical powder fire-extinguishing systems approved by the Administration/ IRS based on MSC .1/Circ 1315 for the purpose of fighting fire on the deck. In the cargo area, including any cargo liquid and vapour discharge and loading connections on deck and bow or stern cargo handling areas, as applicable.

11.4.2 The system is to be capable of delivering powder from at least two hand hose lines or combination monitor/hand hose line(s) to any part of the exposed cargo liquid and vapour piping, load/unload connection and exposed gas process units.

11.4.3 The dry chemical powder fire-extinguishing system is to be designed with not less than two independent units. Any part required to be protected by 11.4.2 is to be capable of being reached form not less than two independent units with associated controls, pressurizing median fixed piping, monitors or hand hose lines. For ships with a cargo capacity of less than 1000 [m^3], only one such unit need be fitted. A monitor is to be arranged to protect any load/unload connection area and be capable of actuation and discharge both locally and remotely. The monitor is not required to be remotely aimed if it can deliver the necessary powder to all required areas of coverage from a single position. One hose line is to be provided at both port- and starboard side at the end of the cargo area facing the accommodation and readily available from the accommodation.

11.4.4 The capacity of a monitor is to be not less than 10 [kg/sec]. Hand hose lines are to be non-kinkable and be fitted with a nozzle capable of on/off operation and discharge at a rate not less than 3.5 [kg/sec]. The maximum discharge rate is to be such as to allow operation by one man. The length of a hand hose line is not to exceed 33 [m]. Where fixed piping is provided between the powder container and a hand hose line or monitor, the length of piping is not to exceed that length which is capable of maintaining the powder in a fluidized state during sustained or intermittent use, and which can be purged of powder when the system is shut down. Hand hose lines and nozzles are to be of weather-resistant construction or stored in weather-resistant housing or covers and be readily accessible.

11.4.5 Hand hose lines are to be considered to have a maximum effective distance of coverage equal to the length of hose. Special consideration would be given where areas to be protected are substantially higher than the monitor or hand hose reel locations.

11.4.6 Ships fitted with bow/stern load/unload connections are to be provided with independent dry powder unit protecting the cargo liquid and vapour piping, aft and forward of cargo area, by hose lines and a monitor covering the bow/stern load/unload complying with the requirements of 11.4.1 to 11.4.5.

11.4.7 Ships intended for operation as listed 1.1.10 are to be subject to special consideration.

11.4.8 After installation, the pipes, valves, fittings and assembled systems are to be subjected to a tightness test and functional testing of the remote and local release stations. The initial testing is also to include a discharge of sufficient amounts of dry chemical powder to verify that the system is in proper working order. All distribution piping is to be blown through with dry air to ensure that the piping is free of obstructions.

11.5 Enclosed spaces containing cargo handling equipment

11.5.1 Enclosed spaces meeting the criteria of cargo machinery spaces in 1.2.10, and the cargo motor room within the cargo area of any ship, are to be provided with a fixed fire-extinguishing system complying with the provisions of the FSS Code and taking into account the necessary concentrations/application rate required for extinguishing gas fires.

11.5.2 Enclosed spaces meeting the criteria of cargo machinery spaces in Sec 3.3, within the cargo area of ships that are dedicated to the carriage of a restricted number of cargoes, are to be protected by an appropriate fire-extinguishing system for the cargo carried.

11.5.3 Turret compartments of any ship are to be protected by internal water spray, with an application rate of not less than 10 [ℓ/m^2/min] of the largest projected horizontal surface. If the pressure of the gas flow through the turret exceeds 4 [MPa], the application rate is to be increased to 20 [ℓ/m^2/min]. The system is to be designed to protect all internal surfaces.

11.6 Fire Fighter's Outfits

IR11.6.1 Every ship carrying flammable products is to carry firefighter's outfits complying with the requirements of Part 4.

11.6.1 Every ship carrying flammable products is to carry firefighter's outfits complying with the requirements of regulation II-2/10.10 of SOLAS (Rules Pt.6, Ch.3, Cl.4.10) as follows:

Total cargo capacity	Number of outfits
5000 [m^3] and below	4
above 5000 [m^3]	5

11.6.2 Additional requirements for safety equipment are given in Sec.14.

11.6.3 Any breathing apparatus required as part of a fireman's outfit is to be a self-contained compressed air-operated breathing apparatus having a capacity of at least 1,200 litres of free air.

Section 12

Artificial Ventilation in Cargo Area

Note: The requirements of this Chapter replace regulation II-2/4.5.2.6 and II-2/4.5.4.1 of SOLAS (Rules Pt.6, Ch.2, Cl.1.5.2.6 and 1.5.4).

12.0 Goal

To ensure that arrangements are provided for enclosed spaces in the cargo area to control the accumulation of flammable and/or toxic vapours.

12.1 Spaces required to be entered during normal cargo handling operations

12.1.1 Electric motor rooms, cargo compressor and pump-rooms, spaces containing cargo handling equipment and other enclosed spaces where cargo vapours may accumulate are to be fitted with fixed artificial ventilation systems capable of being controlled from outside such spaces. The ventilation is to be run continuously to prevent the accumulation of toxic and/or flammable vapours, with a means of monitoring acceptable to the Administration/ IRS to be provided. A warning notice requiring the use of such ventilation prior to entering is to be placed outside the compartment.

12.1.2 Artificial ventilation inlets and outlets are to be arranged to ensure sufficient air movement through the space to avoid accumulation of flammable, toxic or asphyxiant vapours and to ensure a safe working environment.

12.1.3 The ventilation system is to have a capacity of not less than 30 changes of air per hour, based upon the total volume of the space. As an exception, non-hazardous cargo control rooms may have eight changes of air per hour.

12.1.4 Where a space has an opening into an adjacent more hazardous space or area, it is to be maintained at an overpressure. It may be made into a less hazardous space or non-hazardous space by overpressure protection in accordance with recognized standards.

12.1.5 Ventilation ducts, air intakes and exhaust outlets serving artificial ventilation systems are to be positioned in accordance with IEC 60092-502:1999.

12.1.6 Ventilation ducts serving hazardous areas are not to be led through accommodation, service and machinery spaces or control stations, except as allowed in Sec.16.

12.1.7 Electric motors driving fans are to be placed outside the ventilation ducts that may contain flammable vapours. Ventilation fans are not to produce a source of ignition in either the ventilated space or the ventilation system associated with the space. For hazardous areas, ventilation fans and ducts, adjacent to the fans are to be of non-sparking construction, as defined below:

.1 impellers or housing of non-metallic construction, with due regard being paid to the elimination of static electricity;

.2 impellers and housing of non-ferrous materials;

.3 impellers and housing of austenitic stainless steel; and

.4 ferrous impellers and housing with design tip clearance of not less than 13 [mm].

Any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and are not to be used in these places.

12.1.8 Where fans are required by this section, full required ventilation capacity for each space is to be available after failure of any single fan, or spare parts are to be provided comprising a motor, starter spares and complete rotating element, including bearings of each type.

12.1.9 Protection screens of not more than 13 [mm] square mesh are to be fitted to outside openings of ventilation ducts.

12.1.10 Where spaces are protected by pressurization, the ventilation shall be designed and installed in accordance with IEC 60092-502:1999.

12.2 Spaces not normally entered

12.2.1 Enclosed spaces where cargo vapours may accumulate are to be capable of being ventilated to ensure a safe environment when entry into them is necessary. This is to be capable of being achieved without the need for prior entry.

12.2.2 For permanent installations, the capacity of 8 air changes per hour is to be provided and for portable systems, the capacity of 16 air changes per hour.

12.2.3 Fans or blowers are to be clear of personnel access openings, and are to comply with 12.1.7.

Section 13

Instrumentation and Automation Systems

13.0 Goal

To ensure that the instrumentation and automation systems provides for the safe carriage, handling and conditioning of cargo liquid and vapour.

13.1 General

13.1.1 Each cargo tank is to be provided with means for indicating level, pressure and temperature of the cargo. Pressure gauges and temperature indicating devices are to be installed in the liquid and vapour piping systems, in cargo refrigeration installations.

13.1.2 If loading and unloading of the ship is performed by means of remotely controlled valves and pumps, all controls and indicators associated with a given cargo tank are to be concentrated in one control position.

13.1.3 Instruments are to be tested to ensure reliability in the working conditions and recalibrated at regular intervals. Test procedures for instruments and the intervals between recalibration are to be in accordance with manufacturer's recommendations.

13.2 Level indicators for cargo tanks

13.2.1 Each cargo tank is to be fitted with liquid level gauging device(s), arranged to ensure that a level reading is always obtainable whenever the cargo tank is operational. The device(s) are to be designed to operate throughout the design pressure range of the cargo tank and at temperatures within the cargo operating temperature range.

13.2.2 Where only one liquid level gauge is fitted, it is to be arranged so that it can be maintained in an operational condition without the need to empty or gas-free the tank.

13.2.3 Cargo tank liquid level gauges may be of the following types, subject to any special requirements for particular cargoes shown in column "g" in the table of Sec.19.

.1 indirect devices, which determine the amount of cargo by means such as weighing or in-line flow metering ;

.2 closed devices, which do not penetrate the cargo tank, such as devices using radioisotopes or ultrasonic devices;

.3 closed devices, which penetrate the cargo tank, but which form part of a closed system and keep the cargo from being released, such as float type systems, electronic probes, magnetic probes and bubble tube indicators. If a closed gauging device is not mounted directly onto the tank it is to be provided with a shut-off valve located as close as possible to the tank; and

.4 restricted devices, which penetrate the tank and when in use permit a small quantity of cargo vapour or liquid to escape to the atmosphere, such as fixed tube and slip tube gauges. When not in use, the devices are to be kept completely closed. The design and installation is to ensure that no dangerous escape of cargo can take place when opening the device. Such gauging devices are to be so designed that the maximum opening does not exceed 1.5 [mm] diameter or equivalent area, unless the device is provided with an excess flow valve.

IR.4 The openings of restricted devices are to be located on the weather deck and not in enclosed compartments.

13.3 Overflow control

13.3.1 Except as provided in 13.3.4, each cargo tank is to be fitted with a high liquid level alarm operating independently of other liquid level indicators and giving an audible and visual warning when activated.

13.3.2 An additional sensor operating independently of the high liquid level alarm is to automatically actuate a shutoff valve in a manner that will both avoid excessive liquid pressure in the loading line and prevent the tank from becoming liquid full.

13.3.3 The emergency shutdown valve referred to in 5.5 and 18.10 may be used for this purpose. If another valve is used for this purpose, the same information as referred to in 18.10.2.1.3 is to be available on board. During loading, whenever the use of these valves may possibly create a potential excess pressure surge in the loading system, alternative arrangements such as limiting the loading rate is to be used.

13.3.4 A high liquid level alarm and automatic shut-off of cargo tank filling need not be required when the cargo tank:

.1 is a pressure tank with a volume of not more than 200 [m^3]; or

.2 is designed to withstand the maximum possible pressure during the loading operation and such pressure is below that of the set pressure of the cargo tank relief valve.

13.3.5 The position of the sensors in the tank is to be capable of being verified before commissioning. At the first occasion of full loading after delivery and after each dry-docking, testing of high-level alarms is to be conducted by raising the cargo liquid level in the cargo tank to the alarm point.

13.3.6 All elements of the level alarms, including the electrical circuit and the sensor(s), of the high, and overfill alarms, are to be capable of being functionally tested. Systems are to be tested prior to cargo operation in accordance with 18.6.2.

13.3.7 Where arrangements are provided for overriding the overflow control system, they are to be such that inadvertent operation is prevented. When this override is operated, continuous visual indication is to be given at the relevant control station(s) and the navigation bridge.

13.4 Pressure monitoring

13.4.1 The vapour space of each cargo tank is to be provided with a direct reading gauge. Additionally, an indirect indication is to be provided at the control position required by 13.1.2. Maximum and minimum allowable pressures are to be clearly indicated.

13.4.2 A high-pressure alarm and, if vacuum protection is required, a low-pressure alarm is to be provided on the navigation bridge and at the control position required by 13.1.2. Alarms are to be activated before the set pressures are reached.

13.4.3 For cargo tanks fitted with PRVs which can be set at more than one set pressure in accordance with 8.2.7, high-pressure alarms are to be provided for each set pressure.

13.4.4 Each cargo-pump discharge line and each liquid and vapour cargo manifold is to be provided with at least one pressure indicator

13.4.5 Local reading manifold indication is to be provided to indicate the pressure between ship's manifold valves and hose connections to the shore.

13.4.6 Hold spaces and interbarrier spaces without open connection to the atmosphere are to be provided with pressure indication

13.4.7 All pressure indications provided are to be capable of indicating throughout the operating pressure range.

13.5 Temperature indicating devices

13.5.1 Each cargo tank is to be provided with at least two devices for indicating cargo temperatures, one placed at the bottom of the cargo tank and the second near the top of the tank, below the highest allowable liquid level. The lowest temperature for which the cargo tank has been designed, as shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required by 1.4.4, is to be clearly indicated by means of a sign on or near the temperature indicating devices

13.5.2 The temperature indicating devices are to be capable of providing temperature indication across the expected cargo operating temperature range of the cargo tanks.

13.5.3 Where thermowells are fitted, they are to be designed to minimize failure due to fatigue in normal service.

13.6 Gas detection

13.6.1 Gas detection equipment is to be installed to monitor the integrity of the cargo containment, cargo handling and ancillary systems, in accordance with this section.

13.6.2 A permanently installed system of gas detection and audible and visual alarms is to be fitted in :

.1 all enclosed cargo and cargo machinery spaces (including turrets compartments) containing gas piping, gas equipment or gas consumers;

.2 other enclosed or semi-enclosed spaces where cargo vapours may accumulate, including interbarrier spaces and hold spaces for independent tanks other than type C tanks;

.3 airlocks;

.4 spaces in gas-fired internal combustion engines, referred to in 16.7.3.3;

.5 ventilation hoods and gas ducts required by Sec 16;

.6 cooling/heating circuits, as required by 7.8.4;

.7 inert gas generator supply headers; and

.8 motor rooms for cargo handling machinery.

13.6.3 Gas detection equipment is to be designed, installed and tested in accordance with IEC 60079-29-1 and is to be suitable for the cargoes to be carried in accordance with column “f” in table of sec 19.

13.6.4 Where indicated in column "*f*" in the table of Sec 19 ships certified for carriage of non-flammable products, oxygen deficiency monitoring is to be fitted in cargo machinery spaces and cargo tank hold spaces. Furthermore, oxygen deficiency monitoring equipment are to be installed in enclosed or semi-enclosed spaces containing equipment that may cause an oxygen-deficient environment such as nitrogen generators, inert gas generators or nitrogen cycle refrigerant systems.

13.6.5 In the case of toxic products or both toxic and flammable products, except when columns 'i' in the table of section 19 refers to 17.5.3, portable equipment can be used for the detection of toxic products as an alternative to a permanently installed system. This equipment is to be used prior to personnel entering the spaces listed in 13.6.2 and 30-minute intervals while they remain in the space.

13.6.6 In the case of gases classified as toxic products, hold spaces and interbarrier spaces are to be provided with a permanently installed piping system for obtaining gas samples from the spaces. Gas from these spaces is to be sampled and analysed from each sampling head location.

13.6.7 Permanently installed gas detection is to be of the continuous detection type, capable of immediate response. Where not used to activate safety shutdown functions required by 13.6.9 and Sec 16, sampling type detection may be accepted.

13.6.8 When sampling type gas detection equipment is used, the following requirements are to be met:

.1 the gas detection equipment is to be capable of sampling and analysing for each sampling head location sequentially at intervals not exceeding 30 min;

.2 individual sampling lines from sampling heads to the detection equipment is to be fitted; and

.3 pipe runs from sampling heads are not to be led through non-hazardous spaces except as permitted by 13.6.9.

13.6.9 The gas detection equipment may be located in a non-hazardous space, provided that the detection equipment such as sample piping, sample pumps, solenoids and analysing units are located in a fully enclosed steel cabinet with the door sealed by a gasket. The atmosphere within the enclosure is to be continuously monitored. At gas concentrations above 30% lower flammable limit (LFL) inside the enclosure, the gas detection equipment is to be automatically shut down.

13.6.10 Where the enclosure cannot be arranged directly on the forward bulkhead, sample pipes are to be of steel or equivalent material and be routed on their shortest way. Detachable connections, except for the connection points for isolating valves required in 13.6.11 and analysing units, are not permitted.

13.6.11 When gas sampling equipment is located in a non-hazardous space, a flame arrester and a manual isolating valve is to be fitted in each of the gas sampling lines. The isolating valve is to be fitted on the non-hazardous side. Bulkhead penetrations of sample pipes between hazardous and non-hazardous areas are to maintain the integrity of the division penetrated. The exhaust gas is to be discharged to the open air in a safe location.

13.6.12 In every installation, the number and the positions of detection heads are to be determined with due regard to the size and layout of the compartment, the compositions and densities of the products intended to be carried and the dilution from compartment purging or ventilation and stagnant areas.

13.6.13 Any alarms status within a gas detection system required by this section is to initiate an audible and visible alarm:

.1 on the navigation bridge;

.2 at the relevant control station(s) where continuous monitoring of the gas levels is recorded; and

.3 at the gas detector readout location.

13.6.14 In the case of flammable products, the gas detection equipment provided for hold spaces and interbarrier spaces that are required to be inerted are to be capable of measuring gas concentrations of 0% to 100% by volume.

13.6.15 Alarms are to be activated when the vapour concentration by volume reaches the equivalent of 30% LFL in air.

13.6.16 For membrane containment systems, the primary and secondary insulation spaces are to be able to be inerted and their gas content analysed individually (refer to '*Gas Concentration in the insulation Spaces of Membrane LNG Carriers, March 2007'* published by SIGTTO). The alarm in the secondary insulation space is to be set in accordance with 13.6.15, that in the primary space is set at a value approved by IRS.

13.6.17 For other spaces described by 13.6.2, alarms are to be activated when the vapour concentration reaches 30% LFL and safety functions required by Sec 16 are to be activated before the vapour concentration reaches 60% LFL. The crankcases of internal combustion engines that can run on gas are to be arranged to alarm before 100% LFL.

13.6.18 Gas detection equipment is to be so designed that it may readily be tested. Testing and calibration is to be carried out at regular intervals. Suitable equipment for this purpose shall be carried on board and be used in accordance with the manufacturer's recommendations. Permanent connections for such test equipment are to be fitted.

13.6.19 Every ship is to be provided with at least two sets of portable gas detection equipment that meet the requirement of 13.6.3 or an acceptable national or international standard.

13.6.20 A suitable instrument for the measurement of oxygen levels in inert atmospheres is to be provided.

13.7 Additional requirements for containment systems requiring a secondary barrier

13.7.1 Integrity of barriers

Where a secondary barrier is required, permanently installed instrumentation is to be provided to detect when the primary barrier fails to be liquid-tight at any location or when liquid cargo is in contact with the secondary barrier at any location. This instrumentation is to consist of appropriate gas detecting devices according to 13.6. However, the instrumentation need not be capable of locating the area where liquid cargo leaks through the primary barrier or where liquid cargo is in contact with the secondary barrier.

13.7.2 Temperature indication devices

13.7.2.1 The number and position of temperature-indicating devices are to be appropriate to the design of the containment system and cargo operation requirements.

13.7.2.2 When cargo is carried in a cargo containment system with a secondary barrier, at a temperature lower than -55 [°C], temperature-indicating devices are to be provided within the insulation or on the hull structure adjacent to cargo containment systems. The devices are to give readings at regular intervals and, where applicable, alarm of temperatures approaching the lowest for which the hull steel is suitable.

13.7.2.3 If cargo is to be carried at temperatures lower than -55 [°C], the cargo tank boundaries, if appropriate for the design of the cargo containment system, shall be fitted with a sufficient number of temperature-indicating devices to verify that unsatisfactory temperature gradients do not occur.

13.7.2.4 For the purposes of design verification and determining the effectiveness of the initial cooldown procedure on a single or series of similar ships, one tank is to be fitted with devices in excess of those required in 13.7.2.1. These devices may be temporary or permanent and only need to be fitted to the first ship, when a series of similar ships is built.

13.8 Automation systems

13.8.1 The requirements of this Sub-section shall apply where automation systems are used to provide instrumented control, monitoring/alarm or safety functions required by this Chapter.

13.8.2 Automation systems are to be designed, installed and tested in accordance with IEC 60092-504:2001.

13.8.3 Hardware is to be capable of being demonstrated to be suitable for use in the marine environment by type approval or other means.

13.8.4 Software is to be designed and documented for ease of use, including testing, operation and maintenance.

13.8.5 The user interface is to be designed such that the equipment under control can be operated in a safe and effective manner at all times.

13.8.6 Automation systems are to be arranged such that a hardware failure or an error by the operator does not lead to an unsafe condition. Adequate safeguards against incorrect operation are to be provided.

13.8.7 Appropriate segregation is to be maintained between control, monitoring/alarm and safety functions to limit the effect of single failures. This shall be taken to include all parts of the automation systems that are required to provide specified functions, including connected devices and power supplies.

13.8.8 Automation systems are to be arranged such that the software configuration and parameters are protected against unauthorized or unintended change.

13.8.9 A management of change process is to be applied to safeguard against unexpected consequences of modification. Records of configuration changes and approvals are to be maintained on board.

13.8.10 Processes for the development and maintenance of integrated systems are to be in accordance with ISO/IEC 15288:2008 and ISO 17894:2005. These processes are to include appropriate risk identification and management.

13.9 System integration

13.9.1 Essential safety functions are to be designed such that risks of harm to personnel or damage to the installation or the environment are reduced to a level acceptable to the Administration/ IRS, both in normal operation and under fault conditions. Functions are to be designed to fail-safe. Roles and responsibilities for integration of systems are to be clearly defined and agreed by relevant parties.

13.9.2 Functional requirements of each component subsystem are to be clearly defined to ensure that the integrated system meets the functional and specified safety requirements and takes account of any limitations of the equipment under control.

13.9.3 Key hazards of the integrated system are to be identified using appropriate risk-based techniques.

13.9.4 The integrated system is to have a suitable means of reversionary control.

13.9.5 Failure of one part of the integrated system is not to affect the functionality of other parts, except for those functions directly dependent on the defective part.

13.9.6 Operation with an integrated system is to be at least as effective as it would be with individual stand-alone equipment or systems.

13.9.7 The integrity of essential machinery or systems, during normal operation and fault conditions, are to be demonstrated.

Section 14

Personnel Protection

14.0 Goal

To ensure that protective equipment is provided for ship staff, considering both routine operations or emergency situations and possible short- or long-term effects of the product being handled.

14.1 Protective Equipment

14.1.1 Suitable protective equipment including eye protection to a recognized national or international standard, are to be provided for protection of crew members engaged in normal cargo operations, taking into account the characteristics of the products being carried.

14.1.2 Personal protective and safety equipment required in this section are to be kept in suitable, clearly marked lockers located in readily accessible places.

14.1.3 The compressed air equipment is to be inspected at least once a month by a responsible officer and the inspection logged in the ship's records. This equipment is also to be inspected and tested by a competent person at least once a year.

14.2 First-aid equipment

14.2.1 A stretcher that is suitable for hoisting an injured person from spaces below deck is to be kept in a readily accessible location.

14.2.2 The ship is to have onboard medical first-aid equipment, including oxygen resuscitation equipment, based on the requirements of the Medical First Aid Guide (MFAG) for the cargoes listed on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk shown in appendix 5 of IGC Code.

14.3 Safety Equipment

14.3.1 Sufficient, but not less than three complete sets of safety equipment are to be provided in addition to the firemen's outfits required by 11.6.1. Each set is to provide adequate personal protection to permit entry and work in a gas-filled space. This equipment is to take into account the nature of the cargoes, listed on the International Certificate of Fitness for the Carriage of Liquified Gases in Bulk shown in appendix 2 of IGC Code.

14.3.2 Each complete set of safety equipment is to consist of:

.1 one self-contained positive pressure air-breathing apparatus incorporating full face mask, not using stored oxygen and having a capacity of at least 1200 [l] of free air. Each set is to be compatible with that required by 11.6.1;

.2 protective clothing, boots, and gloves to a recognized standard ;

.3 steel cored rescue line with belt; and

.4 explosion-proof lamp.

14.3.3 An adequate supply of compressed air is to be provided and is to consist either of :

.1 at least one fully charged spare air bottles for each breathing apparatus required by 14.3.1;

.2 an air compressor of adequate capacity capable of continuous operation suitable for the supply of high-pressure air of breathable quality; and

.3 a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus required by 14.3.1

14.4 Personnel protection requirement for individual products

14.4.1 Requirements of this sub-section applicable to ships carrying products for which those paragraphs are listed in column "i" in the table 19.1.1.

14.4.2 Suitable respiratory and eye protection for emergency escape purposes are to be provided for every person on board subject to following :

.1 filter type respiratory protection is unacceptable,

.2 self-contained breathing apparatus is to have at least a duration of service of 15 minutes; and

.3 emergency escape respiratory protection is not to be used for fire-fighting or cargo handling purposes and is to be marked to that effect;

14.4.3 One or more suitably marked decontamination showers and an eyewash are to be available on deck, taking into account the size and layout of the ship. The showers and eyewash are to be operable in all ambient conditions.

14.4.4 The protective clothing required under 14.3.2.2 is to be gastight.

Section 15

Filling Limits for Cargo Tanks

15.0 Goal

To determine the maximum quantity of cargo that can be loaded.

15.1 Definitions

15.1.1 *Filling limit (FL)* means the maximum liquid volume in a cargo tank relative to the total tank volume when the liquid cargo has reached the reference temperature.

15.1.2 *Loading limit (LL)* means the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded.

15.1.3 *Reference temperature* means (for the purposes of this section only):

.1 when no cargo vapour pressure/temperature control, as referred to in Sec 7, is provided, the temperature corresponding to the vapour pressure of the cargo at the set pressure of the PRVs; and

.2 when a cargo vapour pressure/temperature control, as referred to in Sec 7, is provided, the temperature of the cargo upon termination of loading, during transport or at unloading, whichever is the greatest.

15.1.4 *Ambient design temperature for unrestricted service* means sea temperature of 32°C and air temperature of 45 [°C]. However, lesser values of these temperatures may be accepted by the Administration/ IRS for ships operating in restricted areas or on voyages of restricted duration, and account may be taken in such cases of any insulation of the tanks. Conversely, higher values of these temperatures may be required for ships permanently operating in areas of high-ambient temperature.

15.2 General requirements

The maximum filling limit of cargo tanks are to be so determined that the vapour space has a minimum volume at reference temperature allowing for:

.1 tolerance of instrumentation such as level and temperature gauges;

.2 volumetric expansion of the cargo between the PRV set pressure and the maximum allowable rise stated in 8.4; and

.3 an operational margin to account for liquid drained back to cargo tanks after completion of loading, operator reaction time and closing time of valves, see 5.5 and 18.10.2.1.4.

15.3 Default filling limit

The default value for the filling limit (*FL*) of cargo tanks is 98% at the reference temperature. Exceptions to this value are to meet the requirements of 15.4.

15.4 Determination of increased filling limit

15.4.1 A filling limit greater than the limit of 98% specified in 15.3 may be permitted under the trim and list conditions specified in 8.2.17, providing:

.1 no isolated vapour pockets are created within the cargo tank;

.2 the PRV inlet arrangement shall remain in the vapour space; and

.3 allowances need to be provided for:

.1 volumetric expansion of the liquid cargo due to the pressure increase from the MARVS to full flow relieving pressure in accordance with 8.4.1;

.2 an operational margin of minimum 0.1% of tank volume; and

.3 tolerances of instrumentation such as level and temperature gauges.

15.4.2 In no case shall a filling limit exceeding 99.5% at reference temperature be permitted.

15.5 Maximum loading limit

15.5.1 The maximum loading limit (LL) to which a cargo tank is to be determined by following formula :

$$LL = FL \frac{d_R}{d_L}$$

where,

LL = loading limit defined in 15.1.2, expressed in percentage

FL = filling limit as specified in 15.3 or 15.4 expressed in percentage

d_R = relative density of cargo at the reference temperature; and

d_L = relative density of cargo at the loading temperature .

15.5.2 IRS may allow type C tanks to be loaded according to the formula in 15.5.1 with relative density d_R as defined below, provided that the tank vent system has been approved in accordance with 8.2.18:

d_R = relative density of cargo at the highest temperature that the cargo may reach upon termination of loading, during transport, or at unloading, under the ambient design temperature conditions described in 15.1.4;

This paragraph does not apply to products requiring a type 1G ship.

15.6 Information to be provided to the master

15.6.1 A document is to be provided to the ship, specifying the maximum allowable loading limit for each cargo tank and product, at each applicable loading temperature and maximum reference temperature. The information in this document is to be approved by IRS.

15.6.2 Pressures at which the PRVs have been set is also to be stated in the document.

15.6.3 A copy of the above document is to be permanently kept on board by the master.

Section 16

Use of Cargo as Fuel

16.0 Goal

To ensure the safe use of cargo as fuel.

16.1 General

Except provided in 16.9, methane (LNG) is the only cargo whose vapour or boil-off gas may be utilized in machinery spaces of category A and in these spaces, it may be utilized only in systems such as boilers, inert gas generators, internal combustion engines, gas combustion unit and gas turbines.

16.2 Use of cargo vapour as fuel

This sub-section addresses the use of cargo vapour as fuel in systems such as boilers, inert gas generators, internal combustion engines, gas combustion units and gas turbines.

16.2.1 For vaporized LNG, the fuel supply system is to comply with the requirements of 16.4.1, 16.4.2 and 16.4.3.

16.2.2 For vaporized LNG, gas consumers are to exhibit no visible flame and are to maintain the uptake exhaust temperature below 535 [°C].

16.3 Arrangement of spaces containing gas consumers

16.3.1 Spaces in which gas consumers are located are to be fitted with a mechanical ventilation system that is arranged to avoid areas where gas may accumulate, taking into account the density of the vapour and potential ignition sources. The ventilation system is to be separated from those serving the other spaces.

16.3.2 Gas detectors are to be fitted in these spaces, particularly where air circulation is reduced. The gas detection system is to comply with the requirements of Sec.13.

16.3.3 Electrical equipment located in the double wall pipe or duct specified in 16.4.3 are to comply with the requirements of Sec 10.

16.3.4 All vents and bleed lines that may contain or be contaminated by gas fuel are to be routed to a safe location external to the machinery space and be fitted with a flame screen.

16.4 Gas fuel supply

16.4.1 General

16.4.1.1 The requirements of this sub-section is applicable to gas fuel supply piping outside of the cargo area. Fuel piping is not to pass through accommodation spaces, service spaces, electrical equipment rooms or control stations. The routeing of the pipeline is to take into account potential hazards, due to mechanical damage, in areas such as stores or machinery handling areas.

16.4.1.2 Provision is to be made for inerting and gas-freeing that portion of the gas fuel piping systems located in the machinery space.

16.4.2 Leak detection

Continuous monitoring and alarms are to be provided to indicate a leak in the piping system in enclosed spaces and shut down the relevant gas fuel supply.

16.4.3 Routeing of fuel supply pipes

Fuel piping may pass through or extend into enclosed spaces other than those mentioned in 16.4.1, provided it fulfill one of the following conditions:

.1 it is of a double-wall design with the space between the concentric pipes pressurized with inert gas at a pressure greater than the gas fuel pressure. The master gas fuel valve, as required by 16.4.6, closes automatically upon loss of inert gas pressure; or

.2 it is installed in a pipe or duct equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes per hour and is arranged to maintain a pressure less than the atmospheric pressure. The mechanical ventilation is in accordance with section 12, as applicable. The ventilation is always in operation when there is fuel in the piping and the master gas fuel valve, as required by 16.4.6, closes automatically if the required air flow is not established and maintained by the exhaust ventilation system. The inlet or the duct may be from a non-hazardous machinery space, and the ventilation outlet is in a safe location.

16.4.4 Requirements for gas fuel with pressure greater than 1 MPa

16.4.4.1 Fuel delivery lines between the high-pressure fuel pumps/compressors and consumers are to be protected with a double-walled piping system capable of containing a high pressure line failure, taking into account the effects of both pressure and low temperature. A single-walled pipe in the cargo area up to the isolating valve(s) required by 16.4.6 is acceptable.

16.4.4.2 The arrangement in 16.4.3.2 may also be acceptable providing the pipe or trunk is capable of containing a high pressure line failure, according to the requirements of 16.4.7 and taking into account the effects of both pressure and possible low temperature and providing both inlet and exhaust of the outer pipe or trunk are in the cargo area.

16.4.5 Gas consumer isolation

The supply piping of each gas consumer unit is to be provided with gas fuel isolation by automatic double block and bleed, vented to a safe location, under both normal and emergency operation. The automatic valves are to be arranged to fail to the closed position on loss of actuating power. In a space containing multiple consumers, the shutdown of one is not to affect the gas supply to the others.

16.4.6 Spaces containing gas consumers

16.4.6.1 It is to be possible to isolate the gas fuel supply to each individual space containing a gas consumer(s) or through which fuel gas supply piping is run, with an individual master valve, which is located within the cargo area. The isolation of gas fuel supply to a space is not to affect the gas supply to other spaces containing gas consumers if they are located in two or more spaces, and it is not to cause loss of propulsion or electrical power.

16.4.6.2 If the double barrier around the gas supply system is not continuous due to air inlets or other openings, or if there is any point where single failure will cause leakage into the space, the individual master valve for the space is to operate under the following circumstances:

.1 automatically by:

.1 gas detection within the space;

.2 leak detection in the annular space of a double-walled pipe;

.3 leak detection in other compartments inside the space, containing single-walled gas piping;

.4 loss of ventilation in the annular space of a double-walled pipe; and

.5 loss of ventilation in other compartments inside the space, containing single-walled gas piping; and

.2 manually from within the space, and at least one remote location.

16.4.6.3 If the double barrier around the gas supply system is continuous, an individual master valve located in the cargo area may be provided for each gas consumer inside the space. The individual master valve is to operate under the following circumstances:

.1 automatically by:

.1 leak detection in the annular space of a double-walled pipe served by that individual master valve;

.2 leak detection in other compartments containing single-walled gas piping that is part of the supply system served by the individual master valve; and

.3 loss of ventilation or loss of pressure in the annular space of a double-walled pipe; and

.2 manually from within the space, and at least one remote location.

16.4.7 Piping and ducting construction

Gas fuel piping in machinery spaces is to comply with 5.1 to 5.9, as applicable. The piping is to, as far as practicable, have welded joints. Those parts of the gas fuel piping that are not enclosed in a ventilated pipe or duct according to 16.4.3, and are on the weather decks outside the cargo area, is to have full penetration butt-welded joints and is to be fully radiographed.

16.4.8 Gas detection

Gas detection systems provided in accordance with the requirements of this section is to activate the alarm at 30% LFL and shut down the master gas fuel valve required by 16.4.6 at not more than 60% LFL (see 13.6.17).

16.5 Gas fuel plant and related storage tanks

16.5.1 Provision of gas fuel

All equipment (heaters, compressors, filters, etc.) for conditioning the gargo and/or cargo boil off vapour for its use as fuel, and any related storage tanks are to be located in the cargo area.If equipment is in an enclosed space, the space is to be ventilated according to 12.1 and be equipped with a fixed fire-fighting system, according to 11.5 and with a gas detection system according to 13.6, as applicable

16.5.2 Remote stops

16.5.2.1 All rotating equipment utilized for conditioning the cargo for its use as fuel are to be arranged for manual remote stop from the engine-room. Additional remote stops are to be located in areas that are always easily accessible, typically cargo control room, navigation bridge and fire control station.

16.5.2.2 The fuel supply equipment is to be automatically stopped in the case of low suction pressure or fire detection. Unless expressly provided otherwise, the requirements of 18.10 need not apply to gas fuel compressors or pumps when used to supply gas consumers.

16.5.3 Heating and cooling mediums

If the heating or cooling medium for the gas fuel conditioning system is returned to spaces outside the cargo area provisions are to be made to detect and alarm the presence of cargo/cargo vapour in the medium. Any vent outlet is to be in a safe position and fitted with an effective flame screen of an approved type.

16.5.4 Piping and pressure vessels

Piping or pressure vessels fitted in the gas fuel supply system are to comply with Sec.5.

16.6 Special requirements for main boilers

16.6.1 Arrangements

16.6.1.1 Each boiler are to have a separate exhaust uptake.

16.6.1.2 Each boiler is to have a dedicated forced draught system. A crossover between boiler force draught systems may be fitted for emergency use providing that any relevant safety functions are maintained.

16.6.1.3 Combustion chambers and uptakes of boilers are to be designed to prevent any accumulation of gaseous fuel.

16.6.2 Combustion equipment

16.6.2.1 The burner systems are to be of dual type, suitable to burn either oil fuel or gas fuel alone or oil and gas fuel simultaneously.

16.6.2.2 Burners are to be designed to maintain stable combustion under all firing conditions.

16.6.2.3 An automatic system is to be fitted to change over from gas fuel operation to oil fuel operation without interruption of the boiler firing, in the event of loss of gas fuel supply.

16.6.2.4 Gas nozzles and the burner control system are to be configured such that gas fuel can only be ignited by an established oil fuel flame, unless the boiler and combustion equipment is designed and approved by recognized organization to light on gas fuel.

16.6.3 Safety

16.6.3.1 There are to be arrangements to ensure that gas fuel flow to the burner is automatically cut-off, unless satisfactory ignition has been established and maintained.

16.6.3.2 On the pipe of each gas-burner, a manually operated shut-off valve shall be fitted.

16.6.3.3 Provisions are to be made for automatically purging the gas supply piping to the burners, by means of an inert gas, after the extinguishing of these burners.

16.6.3.4 The automatic fuel changeover system required by 16.6.2.3 is to be monitored with alarms to ensure continuous availability.

16.6.3.5 Arrangements are to be made that, in case of flame failure of all operating burners, the combustion chambers of the boilers are automatically purged before relighting.

16.6.3.6 Arrangements are to be made to enable the boilers to be manually purged.

16.7 Special requirements for gas-fired internal combustion engines

Dual fuel engines are those that employ gas fuel (with pilot oil) and oil fuel. Oil fuels may include distillate and residual fuels. Gas only engines are those that employ gas fuel only.

16.7.1 Arrangements

16.7.1.1 When gas is supplied in a mixture with air through a common manifold, flame arrestors shall be installed before each cylinder head.

16.7.1.2 Each engine is to have its own separate exhaust.

16.7.1.3 The exhausts are to be configured to prevent any accumulation of unburnt gaseous fuel.

16.7.1.4 Unless designed with the strength to withstand the worst case overpressure due to ignited gas leaks, air inlet manifolds, scavenge spaces, exhaust system and crank cases are to be fitted with suitable pressure relief systems. Pressure relief systems shall lead to a safe location, away from personnel.

16.7.1.5 Each engine is to be fitted with vent systems independent of other engines for crankcases, sumps and cooling systems.

16.7.2 Combustion equipment

16.7.2.1 Prior to admission of gas fuel, correct operation of the pilot oil injection system on each unit is to be verified.

16.7.2.2 For a spark ignition engine, if ignition has not been detected by the engine monitoring system within an engine specific time after opening of the gas supply valve, this is to be automatically shut off and the starting sequence terminated. It is to be ensured that any unburnt gas mixture is purged from the exhaust system.

16.7.2.3 For dual-fuel engines fitted with a pilot oil injection system, an automatic system is to be fitted to change over from gas fuel operation to oil fuel operation with minimum fluctuation of the engine power.

16.7.2.4 In the case of unstable operation on engines with the arrangement in 16.7.2.3 when gas firing, the engine is to automatically change to oil fuel mode.

16.7.3 Safety

16.7.3.1 During stopping of the engine, the gas fuel is to be automatically shut off before the ignition source.

16.7.3.2 Arrangements are to be provided to ensure that there is no unburnt gas fuel in the exhaust gas system prior to ignition.

16.7.3.3 Crankcases, sumps, scavenge spaces and cooling system vents are to be provided with gas detection (see 13.6.17).

16.7.3.4 Provision is to be made within the design of the engine to permit continuous monitoring of possible sources of ignition within the crank case. Instrumentation fitted inside the crankcase is to be in accordance with the requirements of Sec 10.

16.7.3.5 A means is to be provided to monitor and detect poor combustion or misfiring that may lead to unburnt gas fuel in the exhaust system during operation. In the event that it is detected, the gas fuel supply is to be shut down. Instrumentation fitted inside the exhaust system shall be in accordance with the requirements of Sec 10.

16.8 Special requirements for gas turbine

16.8.1 Arrangements

16.8.1.1 Each turbine is to have its own separate exhaust.

16.8.1.2 The exhausts are to be appropriately configured to prevent any accumulation of unburnt gas fuel.

16.8.1.3 Unless designed with the strength to withstand the worst case overpressure due to ignited gas leaks, pressure relief systems are to be suitably designed and fitted to the exhaust system, taking into consideration explosions due to gas leaks. Pressure relief systems within the exhaust uptakes are to be lead to a non-hazardous location, away from personnel.

16.8.2 Combustion equipment

An automatic system is to be fitted to change over easily and quickly from gas fuel operation to oil fuel operation with minimum fluctuation of the engine power.

16.8.3 Safety

16.8.3.1 Means are to be provided to monitor and detect poor combustion that may lead to unburnt gas fuel in the exhaust system during operation. In the event that it is detected, the gas fuel supply is to be shut down.

16.8.3.2 Each turbine is to be fitted with an automatic shutdown device for high exhaust temperatures.

16.9 Alternative fuels and technologies

16.9.1 If acceptable to the Administration/ IRS, other cargo gases may be used as fuel, providing that the same level of safety as natural gas in this Chapter is ensured.

16.9.2 The use of cargoes identified as toxic products are not to be permitted.

16.9.3 For cargoes other than LNG, the fuel supply system is to comply with the requirements of 16.4.1, 16.4.2, 16.4.3 and 16.5, as applicable, and is to include means for preventing condensation of vapour in the system.

16.9.4 Liquefied gas fuel supply systems is to comply with 16.4.5.

16.9.5 In addition to the requirements of 16.4.3.2, both ventilation inlet and outlet is to be located outside the machinery space. The inlet is to be in a non-hazardous area and the outlet is to be in a safe location.

Section 17

Special Requirements

17.0 Goal

To set out the additional requirements in respect of specific cargoes.

17.1 General

The requirements of this Section are applicable where reference thereto is made in column "i" in the table of sec 19. These requirements are additional to the general requirements of the Chapter.

17.2 Materials of construction

Materials that may be exposed to cargo during normal operations are to be resistant to the corrosive action of the gases. In addition, the following materials of construction of cargo tanks, and associated pipelines, valves, fittings and other items of equipment normally in direct contact with cargo liquid or vapour are not to be used for certain products as specified in column "i" in the table of sec 19.

.1 mercury, copper and copper-bearing alloys, and zinc;

.2 copper, silver, mercury, magnesium and other acetylide-forming metals;

.3 aluminum and aluminium-bearing alloys;

.4 copper, copper alloys, zinc and galvanized steel;

.5 aluminum, copper and alloys of either;

.6 copper and copper-bearing alloys with greater than 1 per cent copper.

17.3 Independent tanks

17.3.1 Products are to be carried in independent tanks only.

17.3.2 Products are to be carried in Type C independent tanks and the provisions of 7.1.2 apply. The design pressure of the cargo tank is to take into account any padding pressure or vapour discharge unloading pressure.

17.4 Refrigeration systems

17.4.1 Only the indirect system described in 7.3.1.2 is to be used.

17.4.2 For a ship engaged in the carriage of products that readily form dangerous peroxides, recondensed cargo is not to be allowed to form stagnant pockets of uninhibited liquid. This may be achieved either by:

.1 using the indirect system described in 7.3.1.2 with the condenser inside the cargo tank; or

.2 using the direct system or combined system described in 7.3.1.1 and .3 respectively, or the indirect system described in 7.3.1.2 with the condenser outside the cargo tank, and designing the condensate system to avoid any places in which liquid could collect and be retained. Where this is impossible inhibited liquid is to be added upstream of such a place.

17.4.3 If the ship is to consecutively carry products as specified in 17.4.2 with a ballast passage between, all uninhibited liquid is to be removed prior to the ballast voyage. If a second cargo is to be carried between such consecutive cargoes, the reliquefication system is to be thoroughly drained and purged before loading the second cargo. Purging is to be carried out using either inert gas or vapour from the second cargo, if compatible. Practical steps are to be taken to ensure that polymers or peroxides do not accumulate in the cargo system.

17.5 Cargoes requiring type 1G ship

17.5.1 All butt-welded joints in cargo piping exceeding 75 mm in diameter are to be subject to 100% radiography.

17.5.2 Gas sampling lines are not to be led into or through non-hazardous areas. Alarms referred to in 13.6.2 are to be activated when the vapour concentration reaches the threshold limiting value.

17.5.3 The alternative of using portable gas detection equipment in accordance with 13.6.5 shall not be permitted.

17.5.4 Cargo control rooms are to be located in a non-hazardous area and, additionally, all instrumentation shall be of the indirect type.

17.5.5 Personnel are to be protected against the effects of a major cargo release by the provision of a space within the accommodation area that is designed and equipped to the satisfaction of the Administration/ IRS.

17.5.6 Notwithstanding the requirements in 3.2.4.3, access to forecastle spaces are not to be permitted through a door facing the cargo area, unless airlock in accordance with 3.6 is provided.

17.5.7 Notwithstanding the requirements in 3.2.7, access to control rooms and machinery spaces of turret systems are not to be permitted through doors facing the cargo area.

17.6 Exclusion of air from vapour spaces

Air is to be removed from the cargo tanks and associated piping before loading and then subsequently excluded by:

.1 introducing inert gas to maintain a positive pressure. Storage or production capacity of the inert gas is to be sufficient to meet normal operating requirements and relief valve leakage. The oxygen content of inert gas is at no time to be greater than 0.2 per cent by volume; or

.2 control of cargo temperatures such that a positive pressure is maintained at all times.

17.7 Moisture control

For gases which are non-flammable and may become corrosive or react dangerously with water, moisture control is to be provided to ensure that cargo tanks are dry before loading and that during discharge, dry air or cargo vapour is introduced to prevent negative pressures. For the purposes of this paragraph, dry air is air which has a dewpoint of -45°C or below at atmospheric pressure.

17.8 Inhibition

17.8.1 Care is to be taken to ensure that the cargo is sufficiently inhibited to prevent self-reaction (e.g. polymerization or dimerization) at all times during the voyage. Ships are to be provided with a certificate from the manufacturer stating:

.1 name and amount of inhibitor added;

.2 date inhibitor was added and the normally expected duration of its effectiveness;

.3 any temperature limitations affecting the inhibitor;

.4 the action to be taken when the length of the voyage exceeds the effective lifetime of the inhibitors.

17.9 Flame screens on vent outlets

When carrying a cargo referenced in this section, cargo tank vent outlets are to be provided with readily renewable and effective flame screens or safety heads of an approved type. Due attention is to be paid in the design of flame screens and vent heads to the possibility of the blockage of these devices by the freezing of cargo vapour or by icing up in adverse weather conditions. Flame screens are to be removed and replaced by protection screens, in accordance with 8.2.15, when carrying cargoes not referenced in this section.

17.10 Maximum allowable quantity of cargo per tank

When carrying a cargo referenced to this Section, the quantity of the cargo is not be exceed 3000 [m^3] in any one tank.

17.11 Cargo pumps and discharge arrangements

17.11.1 The vapour space of cargo tanks equipped with submerged electric motor pumps is to be inerted to a positive pressure prior to loading, during carriage and during unloading of flammable liquids.

17.11.2 The cargo is to be discharged only by deepwell pumps or by hydraulically operated submerged pumps. These pumps are to be of a type designed to avoid liquid pressure against the shaft gland.

17.11.3 Inert gas displacement may be used for discharging cargo from type C independent tanks, provided the cargo system is designed for the expected pressure.

17.12 Ammonia

17.12.1 Anhydrous ammonia may cause stress corrosion cracking in containment and process systems made of carbon manganese steel or nickel steel. To minimize the risk of this occurring, measures detailed in 17.12.2 to 17.12.8 are to be taken as appropriate.

17.12.2 Where carbon manganese steel is used, cargo tanks, process pressure vessels and cargo piping are to be made of fine grained steel with a specified minimum yield strength not exceeding 355 [N/mm^2] and with an actual yield strength not exceeding 440 [N/mm^2]. One of the following constructional or operational measures is to also be taken:

.1 lower strength material with a specified minimum tensile strength not exceeding 410 [N/mm^2] is to be used; or

.2 cargo tanks, etc., are to be post weld stress relief heat treated; or

.3 carriage temperature is to be maintained preferably at a temperature close to the product's boiling point of -33°C but in no case at a temperature above -20°C; or

.4 the ammonia is to contain not less than 0.1% w/w water and the master is to be provided with documentation confirming this.

17.12.3 If carbon-manganese steels with higher yield properties are used other than those specified in 17.12.2, the completed cargo tanks, piping, etc. are to be given a post weld stress relief heat treatment.

17.12.4 Process pressure vessels and piping of the condensate part of the refrigeration system is to be given a post-weld stress relief heat treatment when made of materials mentioned in 17.12.1.

17.12.5 The tensile and yield properties of the welding consumables are to exceed those of the tank or piping material by the smallest practical amount.

17.12.6 Nickel steel containing more than 5% nickel and carbon manganese steel, not complying with the requirements of 17.12.2 and 17.12.3 are particularly susceptible to ammonia stress corrosion cracking and are not to be used in containment and piping systems for the carriage of this product.

17.12.7 Nickel steel containing not more than 5% nickel may be used provided the carriage temperature complies with the requirements specified in 17.12.2.3.

17.12.8 To minimize the risk of ammonia stress corrosion cracking, it is advisable to keep the dissolved oxygen content below 2.5 ppm/w/w. This can best be achieved by reducing the average oxygen content in the tanks prior to the introduction of liquid ammonia to less than the values given as a function of the carriage temperature T in the table below:

T (°C)	O_2 (%v/v)
- 30 and below	0.90
-20	0.50
-10	0.28
0	0.16
10	0.10
20	0.05
30	0.03

Oxygen percentages for intermediate temperatures may be obtained by direct interpolation.

17.13 Chlorine

17.13.1 Cargo containment system

17.13.1.1 The capacity of each tank is not to exceed 600 [m^3] and the total capacity of all cargo tanks is not to exceed 1200 [m^3].

17.13.1.2 The tank design vapour pressure is not to be less than 13.5 bar (see also 7.1.2 and 17.3.2).

17.13.1.3 Parts of tanks protruding above the upper deck are to be provided with protection against thermal radiation, taking into account total engulfment by fire.

17.13.1.4 Each tank is to be provided with two pressure relief valves. A bursting disc of appropriate material is to be installed between the tank and the pressure relief valves. The rupture pressure of the bursting disc is to be 1 bar lower than the opening pressure of the pressure relief valve, which is to be set at the design vapour pressure of the tank but not less than 13.5 bar gauge. The space between the bursting disc and the relief valve is to be connected through an excess flow valve to a pressure gauge and a gas detection system. Provision is to be made to keep this space at or near the atmospheric pressure during normal operation.

17.13.1.5 Outlets from pressure relief valves are to be arranged in such a way as to minimize the hazards on board the ship as well as to the environment. Leakage from the relief valves is to be led through the absorption plant to reduce the gas concentration as far as possible. The relief valve exhaust line is to be arranged at the forward end of the ship to discharge outboard at deck level with an arrangement to select either port or starboard side, with a mechanical interlock to ensure that one line is always open.

17.13.1.6 The Administration and the Port Administration may require that chlorine is carried in refrigerated state at a specified maximum pressure.

17.13.2 Cargo piping systems

17.13.2.1 Cargo discharge is to be performed by means of compressed chlorine vapour from shore, dry air or another acceptable gas or fully submerged pumps. Cargo discharge compressors on board ships are not to be used for this.The pressure in the vapour space of the tank during discharging is not to exceed 10.5 bar gauge.

17.13.2.2 The design pressure of the cargo piping system is to be not less than 21 bar gauge. The internal diameter of the cargo pipes is not to exceed 100 mm. Only pipe bends will be accepted for compensation of pipeline thermal movement. The use of flanged joints is to be restricted to a minimum, and when used the flanges are to be of the welding neck type with tongue and groove.

17.13.2.3 Relief valves of the cargo piping system are to discharge to the absorption plant, and the flow restriction creted by this unit is to be taken into account when designing the relief valve system (see 8.4.3 and 8.4.4).

17.13.3 Materials

17.13.3.1 The cargo tanks and cargo piping systems are to be made of steel suitable for the cargo and for a temperature of -40°C, even if a higher transport temperature is intended to be used.

17.13.3.2 The tanks are to be thermally stress relieved. Mechanical stress relief is not to be accepted as an equivalent.

17.13.4 Instrumentation - safety devices

17.13.4.1 The ship is to be provided with a chlorine absorbing plant with connections to the cargo piping system and the cargo tanks. The absorbing plant is to be capable of neutralizing at least 2 per cent of the total cargo capacity at a reasonable absorption rate.

17.13.4.2 During the gas-freeing of cargo tanks, vapours are not to be discharged to the atmosphere.

17.13.4.3 A gas detecting system is to be provided that is capable of monitoring chlorine concentrations of at least 1 ppm by volume. Suction points are to be located:

.1 near the bottom of the hold spaces;

.2 in the pipes from the safety relief valves;

.3 at the outlet from the gas absorbing plant;

.4 at the inlet to the ventilation systems for the accommodation, service and machinery spaces and control stations;

.5 on deck at the forward end, in the middle and at the after end of the cargo area. This is only required to be used during cargo handling and gas-freeing operations.

The gas detection system is to be provided with an audible and visual alarm with a set point of 5 ppm.

17.13.4.4 Each cargo tank is to be fitted with a high-pressure alarm giving an audible alarm at a pressure equal to 10.5 bar gauge.

17.13.5 Personnel protection

The enclosed space required by 17.5.5 is to meet the following requirements :

.1 The space is to be easily and quickly accessible from the weather decks and from accommodation spaces by means of air locks and is to be capable of being rapidly closed gastight.

.2 one of the decontamination showers required by 14.4.3 is to be located near waeather deck airlock to the space;

.3 the space is to be designed to accommodate the entire crew of the ship and be provided with a source of uncontaminated air for a period of not less than 4 h; and

.4 One set of oxygen therapy equipment is to be carried in the space

17.13.6 Filling limits for cargo tanks

17.13.6.1 The requirements of 15.1.3.2 do not apply when it is intended to carry chlorine.

17.13.6.2 The chlorine content of the gas in the vapour space of the cargo tank after loading is to be greater than 80 per cent by volume.

17.14 Ethylene oxide

17.14.1 For the carriage of ethylene oxide the requirements of 17.18 apply, with the additions and modifications as given in this sub-section.

17.14.2 Deck tanks are not to be used for the carriage of ethylene oxide.

17.14.3 Stainless steel types 416 and 442 as well as cast iron are not to be used in ethylene oxide cargo containment and piping systems.

17.14.4 Before loading, tanks are to be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been ethylene oxide, propylene oxide or mixtures of these products. Particular care is to be taken in the case of ammonia in tanks made of steel other than stainless steel.

17.14.5 Ethylene oxide is to be discharged only by deepwell pumps or inert gas displacement. The arrangement of pumps is to comply with 17.18.15.

17.14.6 Ethylene oxide is to be carried refrigerated only and maintained at temperatures of less than 30°C.

17.14.7 Pressure relief valves are to be set at a pressure of not less than 5.5 bar gauge. The maximum set pressure is to be specially approved by Administration/ IRS.

17.14.8 The protective padding of nitrogen gas as required by 17.18.27 is to be such that the nitrogen concentration in the vapour space of the cargo tank will at no time be less than 45 per cent by volume.

17.14.9 Before loading and at all times when the cargo tank contains ethylene oxide liquid or vapour, the cargo tank is to be inerted with nitrogen.

17.14.10 The water-spray system required by paragraph 17.18.29 and that required by 11.3 is to operate automatically in a fire involving the cargo containment system.

17.14.11 A jettisoning arrangement is to be provided to allow the emergency discharge of ethylene oxide in the event of uncontrollable self-reaction.

17.15 Separate piping systems

Separate piping systems, as defined in 1.2.47, are to be provided.

17.16 Methyl acetylene-propadiene mixtures

17.16.1 Methyl acetylene-propadiene mixtures are to be suitably stabilized for transport. Additionally, upper limits of temperature and pressure during the refrigeration are to be specified for the mixtures.

17.16.2 Examples of acceptable, stabilized compositions are:

.1 Composition 1

.1 maximum methyl acetylene to propadiene molar ratio of 3 to 1;

.2 maximum combined concentration of methyl acetylene and propadiene of 65 mol per cent;

.3 minimum combined concentration of propane, butane, and isobutane of 24 mol per cent, of which at least one third (on a molar basis) must be butanes and one third propane; and

.4 maximum combined concentration of propylene and butadiene of 10 mol per cent;

.2 Composition 2

.1 maximum methyl acetylene and propadiene combined concentration of 30 mol per cent;

.2 maximum methyl acetylene concentration of 20 mol per cent;

.3 maximum propadiene concentration of 20 mol per cent;

.4 maximum propylene concentration of 45 mol per cent;

.5 maximum butadiene and butylenes combined concentration of 2 mol per cent;

.6 minimum saturated C4 hydrocarbon concentration of 4 mol per cent; and

.7 minimum propane concentration of 25 mol per cent.

17.16.3 Other compositions may be accepted provided the stability of the mixture is demonstrated to the satisfaction of Administration/ IRS.

17.16.4 If a ship has a, direct vapour compression refrigeration this is to comply with following requirements, subject to pressure and temperature limitations depending on the composition. For the example compositions given in 17.18.2, the following features are to be provided:

.1 A vapour compressor that does not raise the temperature and pressure of the vapour above 60C and 17.5 bar gauge during its operation, and that does not allow vapour to stagnate in the compressor while it continues to run.

.2 Discharge piping from each compressor stage or each cylinder in the same stage of a reciprocating compressor is to have:

.1 two temperature-actuated shutdown switches set to operate at 60C or less;

.2 a pressure-actuated shutdown switch set to operate at 17.5 bar gauge or less; and

.3 a safety relief valve set to relieve at 18.0 bar gauge or less.

.3 The relief valve required by .2.3 is to vent to a mast meeting the requirements of 8.2.10, 8.2.11, and 8.2.15 and is not to relieve into the compressor suction line.

.4 An alarm that sounds in the cargo control position and in the navigation bridge when a high-pressure switch, or a high-temperature switch operates.

17.16.5 The piping system, including the cargo refrigeration system, for tanks to be loaded with methyl acetylene-propadiene mixtures is to be either independent (as defined in 1.2.28) or separate (as defined in 1.2.47) from piping and refrigeration systems for other tanks. This segregation applies to all liquid and vapour vent lines and other possible connections, such as common inert gas supply lines.

17.17 Nitrogen

Materials of construction and ancillary equipment such as insulation are to be resistant to the effects of high oxygen concentrations caused by condensation and enrichment at the low temperatures attained in parts of the cargo system. Due consideration is to be given to ventilation in such areas where condensation might occur to avoid the stratification of oxygen-enriched atmosphere.

17.18 Propylene oxide and mixtures of ethylene oxide-propylene oxide with ethylene oxide content of not more than 30 per cent by weight

17.18.1 Products transported under the provisions of this Section are to be acetylene-free

17.18.2 Unless cargo tanks are properly cleaned, these products are not to be carried in tanks that have contained as one of the three previous cargoes any product known to catalyse polymerization, such as:

.1 anhydrous ammonia and ammonia solutions;

.2 amines and amine solutions;

.3 oxidizing substances (e.g. chlorine).

17.18.3 Before loading, tanks are to be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been propylene oxide or ethylene oxide-propylene oxide mixtures. Particular care is to be taken in the case of ammonia in tanks made of steel other than stainless steel.

17.18.4 In all cases, the effectiveness of cleaning procedures for tanks and associated pipework is to be checked by suitable testing or inspection to ascertain that no traces of acidic or alkaline materials remain that might create a hazardous situation in the presence of these products.

17.18.5 Tanks are to be entered and inspected prior to each initial loading of these products to ensure freedom from contamination, heavy rust deposits and any visible structural defects. When cargo tanks are in continuous service for these products, such inspections are to be performed at intervals of not more than 2 years.

17.18.6 Tanks for the carriage of these products are to be of steel or stainless steel construction.

17.18.7 Tanks which have contained these products may be used for other cargoes after thorough cleaning of tanks and associated pipework systems by washing or purging.

17.18.8 All valves, flanges, fittings and accessory equipment are to be of a type suitable for use with these products and are to be constructed of steel or stainless steel in accordance with recognized standards. Discs or disc faces, seats and other wearing parts of valves are to be made of stainless steel containing not less than 11 per cent chromium.

17.18.9 Gaskets are to be constructed of materials which do not react with, dissolve in, or lower the autoignition temperature of these products and which are fire- resistant and possess adequate mechanical behavior. The surface presented to the cargo is to be polytetrafluoroethylene (PTFE) or materials giving a similar degree of safety by their inertness. Spirally-wound stainless steel with a filler of PTFE or similar fluorinated polymer may be accepted, if approved by IRS.

17.18.10 Insulation and packing if used are to be of a material which does not react with, dissolve in, or lower the autoignition temperature of these products.

17.18.11 The following materials are generally found unsatisfactory for gaskets, packing and similar uses in containment systems for these products and would require testing before being approved :

.1 Neoprene or natural rubber if it comes into contact with the products;

.2 Asbestos or binders used with asbestos;

.3 Materials containing oxides of magnesium, such as mineral wools.

17.18.12 Filling and discharge piping are to extend to within 100 [mm] of the bottom of the tank or any sump .

17.18.13 The products are to be loaded and discharged in such a manner that venting of the tanks to atmosphere does not occur. If vapour return to shore is used during tank loading, the vapour return system connected to a containment system for the product is to be independent of all other containment systems.

17.18.14 During discharging operations, the pressure in the cargo tank is to be maintained above 0.07 bar gauge.

17.18.15 The cargo is to be discharged only by deepwell pumps, hydraulically operated submerged pumps, or inert gas displacement. Each cargo pump is to be arranged to ensure that the products does not heat significantly if the discharge line from the pump is shut off or otherwise blocked.

17.18.16 Tanks carrying these products are to be vented independently of tanks carrying other products. Facilities are to be provided for sampling the tank contents without opening the tank to atmosphere.

17.18.17 Cargo hoses used for transfer of these products are to be marked "FOR ALKYLENE OXIDE TRANSFER ONLY".

17.18.18 Hold spaces are to be monitored for these products. Hold spaces surrounding Type A and B independent tanks are also to be inerted and monitored for oxygen. The oxygen content of these spaces is to be maintained below 2 per cent by volume. Portable sampling equipment is satisfactory.

17.18.19 Prior to disconnecting shore-lines, the pressure in liquid and vapour lines is to be relieved through suitable valves installed at the loading header. Liquid and vapour from these lines are not to be discharged to atmosphere.

17.18.20 Tanks are to be designed for the maximum pressure expected to be encountered during loading, carriage or unloading cargo.

17.18.21 Tanks for the carriage of propylene oxide with a design vapour pressure of less than 0.6 bar and tanks for the carriage of ethylene oxide-propylene oxide mixtures with a design vapour pressure of less than 1.2 bar are to have a cooling system to maintain the cargo below the reference temperature. The reference temperatures are referred to in 15.13.

17.18.22 Pressure relief valve settings is not to be less than 0.2 bar gauge and for Type C independent tanks not greater than 7.0 bar gauge for the carriage of propylene oxide and not greater than 5.3 bar gauge for the carriage of ethylene oxide-propylene oxide mixtures.

17.18.23 The piping system for tanks to be loaded with these products is to be completely separate from piping systems for all other tanks, including empty tanks, and from all cargo compressors. If the piping system for the tanks to be loaded with these products is not independent as defined in 1.2.28 the required piping separation is to be accomplished by the removal of spool pieces, valves, or other pipe sections and the installation of blank flanges at these locations. The required separation applies to all liquid and vapour piping, liquid and vapour vent lines and any other possible connections such as common inert gas supply lines.

17.18.24 The products are to be transported only in accordance with cargo handling plans approved by Administration/ IRS. Each intended loading arrangement is to be shown on a separate cargo handling plan. Cargo handling plans are to show the entire cargo piping system and the locations for installation of blank flanges needed to meet the above piping separation requirements. A copy of each approved cargo handling plan is to be kept on board the ship. The International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk is to be endorsed to include reference to the approved cargo handling plans.

17.18.25 Before each initial loading of the products and before every subsequent return to such service, certification verifying that the required piping separation has been achieved is to be obtained from a responsible person acceptable to the Port Administration and carried on board the ship. Each connection between a blank flange and pipeline flange is to be fitted with a wire and seal by the responsible person to ensure that inadvertent removal of the blank flange is impossible.

17.18.26 The maximum allowable tank loading limits for each cargo tank is to be indicated for each loading temperature that may be applied, in accordance with 15.5.

17.18.27 The cargo is to be carried under a suitable protective padding of nitrogen gas. An automatic nitrogen make-up system is to be installed to prevent the tank pressure falling below 0.07 bar gauge in the event of product temperature fall due to ambient conditions or malfunctioning of refrigeration system. Sufficient nitrogen is to be available on board to satisfy the demand of the automatic pressure control. Nitrogen of commercially pure quality (99,9 per cent by volume) is to be used for padding. A battery of nitrogen bottles connected to the cargo tanks through a pressure reduction valve satisfies the intention of the expression "automatic" in this context.

17.18.28 The cargo tank vapour space is to be tested prior to and after loading to ensure that the oxygen content is 2 per cent by volume or less.

17.18.29 A water-spray system of sufficient capacity is to be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling and the tank domes. The arrangement of piping and nozzles is to be such as to give a uniform distribution rate of 10 [l/m^2] per minute. The arrangement is to ensure that any spilled cargo is washed away.

17.18.30 The water-spray system is to be capable of local and remote manual operation in case of a fire involving the cargo containment system. Remote manual operation is to be arranged such that the remote starting of pumps supplying the water-spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected.

17.18.31 When ambient temperatures permit, a pressurized water hose ready for immediate use shall be available during loading and unloading operations, in addition to the above water-spray requirements.

17.19 Vinyl chloride

In cases where polymerization of vinyl chloride is prevented by addition of an inhibitor, 17.8 is applicable. In cases where no inhibitor has been added or the inhibitor concentration is in sufficient, any inert gas used for the purposes of 17.6 is to contain not more oxygen than 0,1 per cent. Before, loading is started, inert gas samples from the tanks and piping are to be analysed. When vinyl chloride is carried, a positive pressure is always to be maintained in the tanks, and during ballast voyages between successive carriages.

17.20 Mixed C4 cargoes

17.20.1 Cargoes that may be carried individually under the requirements of this chapter, notably butane, butylenes and butadiene, may be carried as mixtures subject to the provisions of this section. These cargoes may variously be referred to as "Crude C4", "Crude butadiene", "Crude steam-cracked C4", "Spent steam-cracked C4", "C4 stream", "C4 raffinate", or may be shipped under a different description. In all cases, the material safety data sheets (MSDS) shall be consulted as the butadiene content of the mixture is of prime concern as it is potentially toxic and reactive. While it is recognized that butadiene has a relatively low vapour pressure, if such mixtures contain butadiene they are to be regarded as toxic and the appropriate precautions applied.

17.20.2 If the mixed C4 cargo shipped under the terms of this section contains more than 50% (mole) of butadiene, the inhibitor precautions in 17.8 applies.

17.20.3 Unless specific data on liquid expansion coefficients is given for the specific mixture loaded, the filling limit restrictions of chapter 15 shall be calculated as if the cargo contained 100% concentration of the component with the highest expansion ratio.

17.21 Carbon dioxide: high purity

17.21.1 Uncontrolled pressure loss from the cargo can cause "sublimation" and the cargo will change from the liquid to the solid state. The precise "triple point" temperature of a particular carbon dioxide cargo is to be supplied before loading the cargo, and will depend on the purity of that cargo, and this is to be taken into account when cargo instrumentation is adjusted. The set pressure for the alarms and automatic actions described in this sub-section are to be set to at least 0.5 Bar (0.05 MPa) above the triple point for the specific cargo being carried. The "triple point" for pure carbon dioxide occurs at 0.5 Bar (0.5 MPa) gauge and -54.4°C.

17.21.2 There is a potential for the cargo to solidify in the event that a cargo tank relief valve, fitted in accordance with 8.2, fails in the open position. To avoid this, a means of isolating the cargo tank safety valves are to be provided and the requirements of 8.2.9.2 do not apply when carrying this carbon dioxide. Discharge piping from safety relief valves are to be designed so they remain free from obstructions that could cause clogging. Protective screens are not to be fitted to the outlets of relief valve discharge piping, so the requirements of 8.2.15 do not apply.

17.21.3 Discharge piping from safety relief valves are not required to comply with 8.2.10, but shall be designed so they remain free from obstructions that could cause clogging. Protective screens are not to be fitted to the outlets of relief valve discharge piping, so the requirements of 8.2.15 do not apply.

17.21.4 Cargo tanks are to be continuously monitored for low pressure when a carbon dioxide cargo is carried. An audible and visual alarm is to be given at the cargo control position and on the bridge. If the cargo tank pressure continues to fall to within 0.5 Bar (0.05 MPa) of the "triple point" for the particular cargo, the monitoring system is to automatically close all cargo manifold liquid and vapour valves and stop all cargo compressors and cargo pumps. The emergency shutdown system required by 18.10 may be used for this purpose.

17.21.5 All materials used in cargo tanks and cargo piping system are to be suitable for the lowest temperature that may occur in service, which is defined as the saturation temperature of the carbon dioxide cargo at the set pressure of the automatic safety system described in 17.21.1.

17.21.6 Cargo hold spaces, cargo compressor rooms and other enclosed spaces where carbon dioxide could accumulate are to be fitted with continuous monitoring for carbon dioxide build-up. This fixed gas detection system replaces the requirements of 13.6, and hold spaces are to be monitored permanently even if the ship has type C cargo containment.

17.22 Carbon dioxide: reclaimed quality

17.22.1 The requirements of 17.21 also apply to this cargo. In addition, the materials of construction used in the cargo system are also to take account of the possibility of corrosion, in case the reclaimed quality carbon dioxide cargo contains impurities such as water, sulphur dioxide, etc., which can cause acidic corrosion or other problems.

Section 18

Operating Requirements

18.0 Goal

To ensure that all ship staff involved in cargo operations have sufficient information about cargo properties and operating the cargo system so they can conduct cargo operations safely.

18.1 General

18.1.1 Those involved in liquefied gas carrier operations are to be made aware of the special requirements associated with, and precautions necessary for, their safe operation.

18.1.2 A copy of the IGC Code, or national regulations incorporating the provisions of the Code, is to be on board every ship covered by the Code.

18.2 Cargo operations manuals

18.2.1 The ship is to be provided with copies of suitably detailed cargo system operation manuals approved by the Administration/ IRS such that trained personnel can safely operate the ship with due regard to the hazards and properties of the cargoes that are permitted to be carried.

18.2.2 The content of the manuals are to include, but not be limited to:

.1 overall operation of the ship from dry-dock to dry-dock, including procedures for cargo tank cooldown and warm-up, transfer (including ship-to-ship transfer), cargo sampling, gas-freeing, ballasting, tank cleaning and changing cargoes;

.2 cargo temperature and pressure control systems;

.3 cargo system limitations, including minimum temperatures (cargo system and inner hull), maximum pressures, transfer rates, filling limits and sloshing limitations;

.4 nitrogen and inert gas systems;

.5 firefighting procedures: operation and maintenance of firefighting systems and use of extinguishing agents;

.6 special equipment needed for the safe handling of the particular cargo;

.7 fixed and portable gas detection;

.8 control, alarm and safety systems;

.9 emergency shutdown systems;

.10 procedures to change cargo tank pressure relief valve set pressures in accordance with 8.2.8 and 4.13.2.3; and

.11 emergency procedures, including cargo tank relief valve isolation, single tank gas-freeing and entry and emergency ship-to-ship transfer operations.

18.3 Cargo information

18.3.1 Information is to be on board and available to all concerned in the form of a cargo information data sheet(s) giving the necessary data for the safe carriage of the cargo. Such information is to include for each product carried:

.1 a full description of the physical and chemical properties necessary for the safe carriage and containment of the cargo;

.2 reactivity with other cargoes that are capable of being carried on board in accordance with the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk;

.3 action to be taken in the event of spills or leaks;

.4 counter measures against accidental personal contact;

.5 fire-fighting procedures and fire-fighting media;

.6 special equipment needed for the safe handling of the particular cargo;

.7 emergency procedures.

18.3.2 The physical data supplied to the master, in accordance with 18.3.1.1, is to include information regarding the relative cargo density at various temperatures to enable the calculation of cargo tank filling limits in accordance with the requirements of sec 15.

18.3.3 Contingency plans in accordance with 18.3.1.3, for spillage of cargo carried at ambient temperature, shall take account of potential local temperature reduction such as when the escaped cargo has reduced to atmospheric pressure and the potential effect of this cooling on hull steel.

18.4 Suitability of carriage

18.4.1 The master is to ascertain that the quantity and characteristics of each product to be loaded are within the limits indicated on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required by 1.4 and in the loading and stability information booklet required by 2.2.5 and that products are listed in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk as required under Sec.4 of the certificate.

18.4.2 Care is to be taken to avoid dangerous chemical reactions if cargoes are mixed. This is of particular significance in respect of:

.1 tank cleaning procedures required between successive cargoes in the same tank; and

.2 simultaneous carriage of cargoes that react when mixed. This is to be permitted only if the complete cargo systems including, but not limited to, cargo pipe work, tanks, vent systems and refrigeration systems are separated as defined in 1.2.27.

18.4.3 Where products are required to be inhibited, the certificate required by 17.8 is to be supplied before departure, otherwise the cargo shall not be transported.

18.5 Carriage of cargo at low temperature

When carrying cargoes at low temperatures:

.1 the cooldown procedure laid down for that particular tank, piping and ancillary equipment is to be followed closely;

.2 loading is to be carried out in such a manner as to ensure that design temperature gradients are not exceeded in any cargo tank, piping or other ancillary equipment; and

.3 if provided, the heating arrangements associated with the cargo containment systems are to be operated in such a manner as to ensure that the temperature of the hull structure does not fall below that for which the material is designed.

18.6 Cargo transfer operations

18.6.1 A pre-cargo operations meeting is to take place between ship personnel and the persons responsible at the transfer facility. Information exchanged is to include the details of the intended cargo transfer operations and emergency procedures. A recognized industry checklist is to be completed for the intended cargo transfer and effective communications shall be maintained throughout the operation.

18.6.2 Essential cargo handling controls and alarms shall be checked and tested prior to cargo transfer operations.

18.7 Personnel training

18.7.1 Personnel are to be adequately trained in the operational and safety aspects of liquefied gas carriers as required by the International Convention on Standards of Training, Certification and Watchkeeping for Seafareres, 1978, as amended, the International Safety Management Code and Medical Firat Aid Guide (MFAG). As a minimum:

.1 All personnel are to be adequately trained in the use of protective equipment provided on board and have basic training in the procedures, appropriate to their duties, necessary under emergency conditions.

.2 Officers are to be trained in emergency procedures to deal with conditions of leakage, spillage or fire involving the cargo and a sufficient number of them are to be instructed and trained in essential first aid for the cargoes carried.

18.8 Entry into enclosed spaces

18.8.1 Under normal operational circumstances, personnel are not to enter cargo tanks, hold spaces, void spaces or other enclosed spaces where gas may accumulate, unless the gas content of the atmosphere in such space is determined by means of fixed or portable equipment to ensure oxygen sufficiency and the absence of toxic atmosphere.

18.8.2 If it is necessary to gas-free and aerate a hold space surrounding a type A cargo tank for routine inspection, and flammable cargo is carried in the cargo tank, the inspection is to be conducted when the tank contains only the minimum amount of cargo "heel" to keep the cargo tank cold. The hold is to be re-inerted as soon as the inspection is completed.

18.8.3 Personnel entering any space designated as hazardous area on a ship carrying flammable products are not to introduce any potential source of ignition into the space unless it has been certified gas-free and is maintained in that condition.

18.9 Cargo sampling

18.9.1 Any cargo sampling is to be conducted under the supervision of an officer who is to ensure that protective clothing appropriate to the hazards of the cargo is used by everyone involved in the operation.

18.9.2 When taking liquid cargo samples, the officer shall ensure that the sampling equipment is suitable for the temperatures and pressures involved, including cargo pump discharge pressure, if relevant.

18.9.3 The officer is to ensure that any cargo sample equipment used is connected properly to avoid any cargo leakage.

18.9.4 If the cargo to be sampled is a toxic product, the officer is to ensure that a "closed loop" sampling system as defined in 1.2.15 is used to minimize any cargo release to atmosphere.

18.9.5 After sampling operations are completed, the officer is to ensure that any sample valves used are closed properly and the connections used are correctly blanked.

18.10 Cargo emergency shutdown (ESD) system

18.10.1 General

18.10.1.1 A cargo emergency shutdown system is to be fitted to stop cargo flow in the event of an emergency, either internally within the ship, or during cargo transfer to ship or shore. The design of the ESD system is to avoid the potential generation of surge pressures within cargo transfer pipe work (see 18.10.2.1.4).

18.10.1.2 Auxiliary systems for conditioning the cargo that use toxic or flammable liquids or vapours are to be treated as cargo systems for the purposes of ESD. Indirect refrigeration systems using an inert medium, such as nitrogen, need not be included in the ESD function.

18.10.1.3 The ESD system is to be activated by the manual and automatic initiations listed in table 18.1. Any additional initiations are only to be included in the ESD system if it can be shown that their inclusion does not reduce the integrity and reliability of the system overall.

18.10.1.4 Ship's ESD systems are to incorporate a ship-shore link in accordance with ISO 28460:2010 .

18.10.1.5 A functional flow chart of the ESD system and related systems shall be provided in the cargo control station and on the navigation bridge.

18.10.2 ESD valve requirements

18.10.2.1 General

18.10.2.1.1 The term *ESD valve* means any valve operated by the ESD system.

18.10.2.1.2 ESD valves are to be remotely operated, be of the fail-closed type (closed on loss of actuating power), be capable of local manual closure and have positive indication of the actual valve position. As an alternative to the local manual closing of the ESD valve, a manually operated shut-off valve in series with the ESD valve shall be permitted. The manual valve shall be located adjacent to the ESD valve. Provisions are to be made to handle trapped liquid should the ESD valve close while the manual valve is also closed.

18.10.2.1.3 ESD valves in liquid piping systems are to close fully and smoothly within 30 s of actuation. Information about the closure time of the valves and their operating characteristics shall be available on board, and the closing time shall be verifiable and repeatable.

18.10.2.1.4 The closing time of the valve referred to in 13.3.1 to 13.3.3 (i.e. time from shutdown signal initiation to complete valve closure) shall not be greater than:

$$\frac{3600U}{LR}\ Seconds$$

Where:

U = ullage volume at operating signal level (m^3);

LR = maximum loading rate agreed between ship and shore facility (m^3/h).

The loading rate is to be adjusted to limit surge pressure on valve closure to an acceptable level, taking into account the loading hose or arm, the ship and the shore piping systems, where relevant.

18.10.2.2 Ship-shore and ship-ship manifold connections

One ESD valve is to be provided at each manifold connection. Cargo manifold connections not being used for transfer operations are to be blanked with blank flanges rated for the design pressure of the pipeline system.

18.10.2.3 Cargo system valves

If cargo system valves as defined in section 5.5 are also ESD valves within the meaning of 18.10, then the requirements of 18.10 applies.

18.10.3 ESD system controls

18.10.3.1 As a minimum, the ESD system is to be capable of manual operation by a single control on the bridge and either in the control position required by 13.1.2 or the cargo control room, if installed, and no less than two locations in the cargo area.

18.10.3.2 The ESD system is to be automatically activated on detection of a fire on the weather decks of the cargo area and/or cargo machinery spaces. As a minimum, the method of detection used on the weather decks shall cover the liquid and vapour domes of the cargo tanks, the cargo manifolds and areas where liquid piping is dismantled regularly. Detection may be by means of fusible elements designed to melt at temperatures between 98°C and 104°C, or by area fire detection methods.

18.10.3.3 Cargo machinery that is running is to be stopped by activation of the ESD system in accordance with the cause and effect matrix in table 18.1.

18.10.3.4 The ESD control system is to be configured so as to enable the high-level testing required in 13.3.5 to be carried out in a safe and controlled manner. For the purpose of the testing, cargo pumps may be operated while the overflow control system is overridden. Procedures for level alarm testing and re-setting of the ESD system after completion of the high-level alarm testing shall be included in the operation manual required by 18.2.1.

18.10.4 Additional shutdowns

18.10.4.1 The requirements of 8.3.1.1 to protect the cargo tank from external differential pressure may be fulfilled by using an independent low pressure trip to activate the ESD system, or, as minimum, to stop any cargo pumps or compressors.

18.10.4.2 An input to the ESD system from the overflow control system required by 13.3 may be provided to stop any cargo pumps or compressors' running at the time a high level is detected, as this alarm may be due to inadvertent internal transfer of cargo from tank to tank.

18.10.5 Pre-operations testing

Cargo emergency shutdown and alarm systems involved in cargo transfer is to be checked and tested before cargo handling operations begin.

18.11 Hot work on or near cargo containment systems

18.11.1 Special fire precautions are to be taken in the vicinity of cargo tanks and, particularly, insulation systems that may be flammable or contaminated with hydrocarbons or that may give off toxic fumes as a product of combustion.

18.12 Additional operating requirements

Additional operating requirements will be found in the following paragraphs of this Chapter:

2.2.2, 2.2.5, 2.2.8, 3.8.4, 3.8.5,5.3.2, 5.3.3.3, 5.7.3, 7.1, 8.2.7,8.2.8, 8.2.9, 9.2, 9.3, 9.4.4, 12.1.1, 13.1.3, 13.3.6, 13.6.18, 14.3.3, 15.3, 16.6.3, 17.4.2, 17.6, 17.7, 17.9, 17.10, 17.11, 17.12, 17.13, 17.14, 17.16, 17.18,17.19, 17.21, 17.22.

	Pumps		Compressor systems				Valves	Link
Shut down action Initiation	Cargo pumps/Cargo booster pumps	Spray/stripping pumps	Vapour return compressors	Fuel gas compressors	Reliquification *** plant including condensante return pumps, if fitted	Gas combustion unit	ESD Valve	Signal to ship/shore link***
Emergency push buttons (see 18.10.3.1)	✓	✓	✓	Note 2	✓	✓	✓	✓
Fire detection on deck or in compressor house* (see 18.10.3.2	✓	✓	✓	✓	✓	✓	✓	✓
High level in cargo tank (see 13.3.2 and 13.3.3)	✓	✓	✓	Note 1, Note 2	Note 1, Note 3	Note 1	Note 6	✓
Signal from ship/shore link (see 18.10.1.4)	✓	✓	✓	Note 2	Note 3	n/a	✓	n/a
Loss of motive power to ESD Valves**	✓	✓	✓	Note 2	Note 3	n/a	✓	✓
Main electric power failure ("blackout")	Note 7	Note 7	Note 7	Note 7	Note 7	Note 7	✓	✓
Level alarm override (see 13.3.7)	Note 4	Note 4, Note 5	✓	Note 1	Note 1	Note 1	✓	✓

Note 1: These items of equipment can be omitted from these specific automatic shutdown initiators, provided the equipment inlets are protected against cargo liquid ingress.

Note 2: If the fuel gas compressor is used to return cargo vapour to shore, it shall be included in the ESD system when operating in this mode.

Note 3: If the reliquefaction plant compressors are used for vapour return/shore line clearing, they shall be included in the ESD system when operating in that mode.

Note 4: The override system permitted by 13.3.7 may be used at sea to prevent false alarms or shutdowns. When level alarms are overridden, operation of cargo pumps and the opening of manifold ESD valves shall be inhibited except when high-level alarm testing is carried out in accordance with 13.3.5 (see 18.10.3.4).

Note 5: Cargo spray or stripping pumps used to supply forcing vaporizer may be excluded from the ESD system only when operating in that mode.

Note 6: The sensors referred to in 13.3.2 may be used to close automatically the tank filling valve for the individual tank where the sensors are installed, as an alternative to closing the ESD valve referred to in 18.10.2.2. If this option is adopted, activation of the full ESD system shall be initiated when the high-level sensors in all the tanks to be loaded have been activated.

Note 7: These items of equipment shall be designed not to restart upon recovery of main electric power and without confirmation of safe conditions.

* Fusible plugs, electronic point temperature monitoring or area fire detection may be used for this purpose on deck.

** Failure of hydraulic, electric or pneumatic power for remotely operated ESD valve actuators.
*** Indirect refrigeration systems which form part of the reliquefaction plant do not need to be included in the ESD function if they employ an inert medium such as nitrogen in the refrigeration cycle.

**** Signal need not indicate the event initiating ESD.

✓ Functional requirement.

N/A Not applicable.

Section 19

Summary of Minimum Requirements

19.1 General

19.1.1 The summary of the requirements of this Chapter is given in Table 19.1.1.

19.1.2 Explanatory notes to the summary of minimum requirements :

Product name *(column a)*	The product name is to be used in the shipping document for any cargo offered for bulk shipments. Any additional name may be included in brackets after the product name. In some cases, the product names are not identical with the names given in previous issues of the IGC Code.
(column b)	Deleted
Ship type *(column c)*	1: Ship type 1G (2.1.2.1) 2: Ship type 2G (2.1.2.2) 3: Ship type 2PG (2.1.2.3) 4: Ship type 3G (2.1.2.4)
Independent tank type C required *(column d)*	Type C independent tank (4.23)
Tank environmental control *(column e)*	Inert: Inerting (9.4) Dry: Drying (17.7) - : No special requirements under the Code
Vapour detection *(column f)*	F: Flammable vapour detection T: Toxic vapour detection F+T: Flammable and toxic vapour detection A: Asphixiant
Gauging *(column g)*	I: Indirect or closed (13.2.3.1 and .2) R: Indirect, closed or restricted (13.2.3.1, .2, .3 and .4) C: Indirect or closed (13.2.3.1, .2 and .3)
(column h)	Deleted
Special requirements *(column i)*	When specific reference is made to chapters 14 and/or 17, these requirements shall be additional to the requirements in any other column.
Refrigerant gases	Non-toxic and non-flammable gases

Unless otherwise specified, gas mixtures containing less than 5% total acetylenes may be transported with no further requirements than those provided for the major components.

Table 19.1.1 : Summary of minimum requirements								
a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
Product name	**-**	**Ship type**	**Independent tank type C required**	**Control of vapour space within cargo tanks**	**Vapour detection**	**Gauging**	**-**	**Special requirements**
Acetaldehyde	-	2G/2PG	-	Inert	F+T	C	-	14.4.3, 14.3.3.1, 17.4.1, 17.6.1
Ammonia, anhydrous	-	2G/2PG	-	-	T	C		14.4, 17.2.1, 17.12
Butadiene (all isomers)	-	2G/2PG	-	-	F+T	R	-	14.4, 17.2.2, 17.4.2, 17.4.3, 17.6, 17.8
Butane (all isomers)	-	2G/2PG	-	-	F	R	-	
Butane/Propane mixtures	-	2G/2PG	-	-	F	R	-	
Butylenes (all isomers)	-	2G/2PG	-	-	F	R	-	
Carbon dioxide (high purity)	-	3G	-	-	A	R	-	17.21
Carbon dioxide (Reclaimed quality)	-	3G	-	-	A	R	-	17.22
Chlorine	-	1G	Yes	Dry	T	I	-	14.4, 17.3.2, 17.4.1, 17.5, 17.7, 17.9, 17.13
Diethyl ether*	-	2G/2PG	-	Inert	F+T	C	-	14.4.2, 14.4.3, 17.2.6, 17.3.1, 17.6.1, 17.9, 17.10, 17.11.2, 17.11.3
Dimethylamine	-	2G/2PG	-	-	F+T	C	-	14.4, 17.2.1
Dimethyl ether	-	2G/2PG	-	-	F+T	C	-	
Ethane	-	2G	-	-	F	R	-	
Ethyl Chloride	-	2G/2PG	-	-	F+T	C	-	
Ethylene	-	2G	-	-	F	R	-	
Ethylene Oxide	-	1G	Yes	Inert	F+T	C	-	14.4, 17.2.2, 17.3.2, 17.4.1, 17.5, 17.6.1, 17.14

a	b	c	d	e	f	g	h	i
Product name	**-**	**Ship type**	**Independent tank type C required**	**Control of vapour space within cargo tanks**	**Vapour detection**	**Gauging**	**-**	**Special requirements**
Ethylene oxide-propylene oxide mixtures with ethylene oxide content of not more than 30% by weight*	-	2G/2PG	-	Inert	F+T	C	-	14.4.3, 17.3.1, 17.4.1, 17.6.1, 17.9, 17.10, 17.18
Isoprene* (all isomers)	-	2G/2PG	-	-	F	R	-	14.4.3, 17.8, 17.9, 17.11.1
Isoprene (Part refined)*	-	2G/2PG	-	-	F	R	-	14.4.3, 17.8, 17.9, 17.11.1
Isopropylamine*	-	2G/2PG	-	-	F+T	C	-	14.4.2, , 17.2.3, 17.3.2, 17.4.1, 17.5
Methane (LNG)	-	2G	-	-	F	C	-	
Methyl Acetylene-Propadiene mixture	-	2G/2PG	-	-	F	R	-	17.16
Methyl Bromide	-	1G	Yes	-	F+T	C	-	14.4, 17.2.3, 17.3.2, 17.4.1, 17.5,
Methyl Chloride	-	2G/2PG	-	-	F+T	C	-	17.2.3
Mixed C4 Cargoes	-	2G/2PG	-	-	F + T	C	-	14.4, 17.2.2, 17.4.2, 17.4.3, 17.6, 17.20
Monoethylamine*	-	2G/2PG	-	-	F+T	C	-	14.4, 17.2.1, 17.3.1, 17.9, 17.10, 17.11.1, 17.15
Nitrogen	-	3G	-	-	A	C	-	17.17
Pentanes (all isomers)*	-	2G/2PG	-	-	F	R	-	17.9, 17.11
Pentenes (all isomers)*	-	2G/2PG	-	-	F	R	-	17.9, 17.11
Propane	-	2G/2PG	-	-	F	R	-	
Propylene	-	2G/2PG	-	-	F	R	-	

a	b	c	d	e	f	g	h	i
Product name	**-**	**Ship type**	**Indepen dent tank type C requi- red**	**Control of vapour space within cargo tanks**	**Vapour detec- tion**	**Gau- ging**	**-**	**Special require- ments**
Propylene oxide*	-	2G/2PG	-	Inert	F+T	C	-	14.4.3, 17.3.1, 17.4.1, 17.6.1, 17.9, 17.10, 17.18
Refrigerant Gases	-	3G	-	-	-	R	-	
Sulphur Dioxide	-	1G	Yes	Dry	T	C	-	14.4, 17.3.2, 17.4.1, 17.5, 17.7
Vinyl Chloride	-	2G/2PG	-	-	F+T	C	-	14.4.2, 17.2.2, 17.2.3, 17.3.1, 17.6, 17.19
Vinyl ethyl ether*	-	2G/2PG	-	Inert	F+T	C	-	14.4.2, 17.2.2, 17.3.1, 17.6.1, 17.8, 17.9, 17.10, 17.11.2, 17.11.3
Vinylidene chloride*	-	2G/2PG	-	Inert	F+T	R	-	14.4.2, 17.2.5, 17.6.1, 17.8, 17.9, 17.10

*** The cargo are covered also by Rules for Chemical Carriers**

APPENDIX 4 of IGC Code- NON-METALLIC MATERIALS

1 General

1.1 The guidance given in this appendix is in addition to the requirements of 4.19, where applicable to non-metallic materials.

1.2 The manufacture, testing, inspection and documentation of non-metallic materials are to in general comply with recognized standards, and with the specific requirements of this chapter, as applicable.

1.3 When selecting a non-metallic material, the designer should ensure that it has properties appropriate to the analysis and specification of the system requirements. A material can be selected to fulfill one or more requirements.

1.4 A wide range of non-metallic materials may be considered. Therefore, the section below on material selection criteria cannot cover every eventuality and should be considered as guidance.

2 Material selection criteria

2.1 Non-metallic materials may be selected for use in various parts of liquefied gas carrier cargo systems based on consideration of the following basic properties:

.1 insulation – the ability to limit heat flow;

.2 load bearing – the ability to contribute to the strength of the containment system;

.3 tightness – the ability to provide liquid and vapour tight barriers;

.4 joining – the ability to be joined (for example by bonding, welding or fastening).

2.2 Additional considerations may apply depending on the specific system design.

3 Properties of materials

3.1 Flexibility of insulating material is the ability of an insulating material to be bent or shaped easily without damage or breakage.

3.2 Loose fill material is a homogeneous solid generally in the form of fine particles, such as a powder or beads, normally used to fill the voids in an inaccessible space to provide an effective insulation.

3.3 Nanomaterial is a material with properties derived from its specific microscopic structure.

3.4 Cellular material is a material type containing cells that are either open, closed or both and which are dispersed throughout its mass.

3.5 Adhesive material is a product that joins or bonds two adjacent surfaces together by an adhesive process.

3.6 Other materials are materials that are not characterized in this section of the Chapter and are to be identified and listed. The relevant tests used to evaluate the suitability of material for use in the cargo system should be identified and documented.

4 Material selection and testing requirements

4.1 **Material specification**

4.1.1 When the initial selection of a material has been made, tests are to be conducted to validate the suitability of this material for the use intended.

4.1.2 The material used is to clearly be identified and the relevant tests should be fully documented.

4.1.3 Materials should be selected according to their intended use. They are :

.1 to be compatible with all the products that may be carried;

.2 not to be contaminated by any cargo nor react with it;

.3 not to have any characteristics or properties affected by the cargo; and

.4 to be capable to withstand thermal shocks within the operating temperature range.

.2 ***Material testing***

The tests required for a particular material depend on the design analysis, specification and intended duty. The list of tests below is for illustration. Any additional tests required, for example in respect of sliding, damping and galvanic insulation, is to be identified clearly and documented. Materials selected according to 4.1 of this appendix is to be tested further according to the following table:

Function	**Insulation**	**Load bearing structural**	**Tightness**	**Joining**
Mechenical Tests		**X**		**X**
Tightness Tests			**X**	
Thermal tests	**X**			

Thermal shock testing is to subject the material and/or assembly to the most extreme thermal gradient it will experience when in service.

4.2.1 Inherent properties of materials

4.2.1.1 Tests are to be carried out to ensure that the inherent properties of the material selected will not have any negative impact in respect of the use intended.

4.2.1.2 For all selected materials, the following properties are to be evaluated:

1 density; example standard ISO 845; and

.2 linear coefficient of thermal expansion (LCTE); example standard ISO 11359 across the widest specified operating temperature range. However, for loose fill material the volumetric coefficient of thermal expansion (VCTE) should be evaluated, as this is more relevant.

4.2.1.3 Irrespective of its inherent properties and intended duty, all materials selected should be tested for the design service temperature range down to 5°C below the minimum design temperature, but not lower than -196°C.

4.2.1.4 Each property evaluation test is to be performed in accordance with recognized standards. Where there are no such standards, the test procedure proposed is to be fully detailed and submitted to the Administration/ IRS for acceptance. Sampling is to be sufficient to ensure a true representation of the properties of the material selected.

4.2.2 Mechanical tests

4.2.2.1 The mechanical tests are to be performed in accordance with the following table.

Mechanical Tests	**Load bearing structural**
Tensile	**ISO 527** **ISO 1421** **ISO 3346** **ISO 1926**
Shearing	**ISO 4587** **ISO 3347** **ISO 1922** **ISO 6237**
Compressive	**ISO 604** **ISO 844** **ISO 3132**
Bending	**ISO 3133** **ISO 14679**
Creep	**ISO 7850**

4.2.2.2 If the chosen function for a material relies on particular properties such as tensile, compressive and shear strength, yield stress, modulus or elongation, these properties is to be tested to a recognized standard. If the properties required are assessed by numerical simulation according to a high order behaviour law, the testing is to be performed to the satisfaction of the Administration/ IRS.

4.2.2.3 Creep may be caused by sustained loads, for example cargo pressure or structural loads. Creep testing is to be conducted based on the loads expected to be encountered during the design life of the containment system.

4.2.3 Tightness tests

4.2.3.1 The tightness requirement for the material is to relate to its operational functionality.

4.2.3.2 Tightness tests are to be conducted to give a measurement of the material's permeability in the configuration corresponding to the application envisaged (e.g. thickness and stress conditions) using the fluid to be retained (e.g. cargo, water vapour or trace gas).

4.2.3.3 The tightness tests are to be based on the tests indicated as examples in the following table.

Tightness Test	Tightness
Porosity/Permeability	ISO 15106 ISO 2568 ISO 2782

4.2.4 Thermal conductivity tests

4.2.4.1 Thermal conductivity tests are to be representative of the lifecycle of the insulation material so its properties over the design life of the cargo system can be assessed. If these properties are likely to deteriorate over time, the material is to be aged as best possible in an environment corresponding to its lifecycle, for example operating temperature, light, vapour and installation (e.g. packaging, bags, boxes, etc.).

4.2.4.2 Requirements for the absolute value and acceptable range of thermal conductivity and heat capacity is to be chosen taking into account the effect on the operational efficiency of the cargo containment system. Particular attention should also be paid to the sizing of the associated cargo handling system and components such as safety relief valves plus vapour return and handling equipment.

4.2.4.3 Thermal tests are to be based on the tests indicated as examples in the following table or their equivalents:

Thermal tests	**Insulating**
Thermal conductivity	**ISO 8301** **ISO 8302**
Heat capacity	**x**

4.2.5 Physical tests

4.2.5.1 In addition to the requirements of 4.19.2.3 and 4.19.3.2, the following table provides guidance and information on some of the additional physical tests that may be considered.

Physical tests	Flexible Insulating	Loose Fill	Nano-material	Cellular	Adhesive
Particle size		X			
Closed cells content				ISO 4590	
Absorption/Desorption	ISO 12571	X	X	ISO 2896	
Viscosity			X		ISO 2555 ISO 2431
Open time					ISO 10364
Thixotropic properties					X
Hardness					ISO 868

4.2.5.2 Requirements for loose fill material segregation is to be chosen considering its potential adverse effect on the material properties (density, thermal conductivity) when subjected to environmental variations such as thermal cycling and vibration.

4.2.5.3 Requirements for a material with closed cell structures is to be based on its eventual impact on gas flow and buffering capacity during transient thermal phases.

4.2.5.4 Similarly, adsorption and absorption requirements is to take into account the potential adverse effect an uncontrolled buffering of liquid or gas may have on the system.

5 Quality assurance and quality control (QA/QC)

5.1 ***General***

5.1.1 Once a material has been selected, after testing as outlined in section 4 of this appendix, a detailed quality assurance/quality control (QA/QC) programme is to be applied to ensure the continued conformity of the material during installation and service. This programme is to consider the material starting from the manufacturer's quality manual (QM) and then follow it throughout the construction of the cargo system.

5.1.2 The QA/QC programme is to include the procedure for fabrication, storage, handling and preventive actions to guard against exposure of a material to harmful effects. These may include, for example, the effect of sunlight on some insulation materials or the contamination of material surfaces by contact with personal products such as hand creams. The sampling methods and the frequency of testing in the QA/QC programme is to be specified to ensure the continued conformity of the material selected throughout its production and installation.

5.1.3 Where powder or granulated insulation is produced, arrangements are to be made to prevent compacting of the material due to vibrations.

5.2 ***QA/QC during component manufacture***

The QA/QC programme in respect of component manufacture is to include, as a minimum but not limited to, the following items.

5.2.1 Component identification

5.2.1.1 For each material, the manufacturer is to implement a marking system to clearly identify the production batch. The marking system is not to interfere, in any way, with the properties of the product.

5.2.1.2 The marking system is to ensure complete traceability of the component and is to include:

> .1 date of production and potential expiry date;
>
> .2 manufacturer's references;
>
> .3 reference specification;
>
> .4 reference order; and
>
> .5 when necessary, any potential environmental parameters to be maintained during transportation and storage.

5.2.2 Production sampling and audit method

5.2.2.1 Regular sampling is required during production to ensure the quality level and continued conformity of a selected material.

5.2.2.2 The frequency, the method and the tests to be performed are to be defined in QA/QC programme; for example, these tests will usually cover, inter alia, raw materials, process parameters and component checks.

5.2.2.3 Process parameters and results of the production QC tests are to be in strict accordance with those detailed in the QM for the material selected.

5.2.2.4 The objective of the audit method as described in the QM is to control the repeatability of the process and the efficacy of the QA/QC programme.

5.2.2.5 During auditing, auditors are to be provided with free access to all production and QC areas. Audit results are to be in accordance with the values and tolerances as stated in the relevant QM.

6 Bonding and joining process requirement and testing

6.1 ***Bonding procedure qualification***

6.1.1 The bonding procedure specification and qualification test is to be defined in accordance with recognized standards.

6.1.2 The bonding procedures are to be fully documented before work commences to ensure the properties of the bond are acceptable.

6.1.3 The following parameters are to be considered when developing a bonding procedure specification:

> .1 surface preparation;
>
> .2 materials storage and handling prior to installation;
>
> .3 covering-time;
>
> .4 open-time;
>
> .5 mixing ratio, deposited quantity;
>
> .6 environmental parameters (temperature, humidity); and
>
> .7 curing pressure, temperature and time.

6.1.4 Additional requirements may be included as necessary to ensure acceptable results.

6.1.5 The bonding procedures specification is to be validated by an appropriate procedure qualification testing programme.

6.2 ***Personnel qualifications***

6.2.1 Personnel involved in bonding processes are to be trained and qualified to recognized standards.

6.2.2 Regular tests are to be made to ensure the continued performance of people carrying out bonding operations to ensure a consistent quality of bonding.

7 Production bonding tests and controls

7.1 ***Destructive testing***

During production, representative samples are to be taken and tested to check that they correspond to the required level of strength as required for the design.

7.2 ***Non-destructive testing***

7.2.1 During production, tests which are not detrimental to bond integrity is to be performed using an appropriate technique such as:

.1 visual examination;

.2 internal defects detection (for example acoustic, ultrasonic or shear test); and

.3 local tightness testing.

7.2.2 If the bonds have to provide tightness as part of their design function, a global tightness test of the cargo containment system is to be completed after the end of the erection in accordance with the designer's and QA/QC programme.

7.2.3 The QA/QC standards are to include acceptance standards for the tightness of the bonded components when built and during the lifecycle of the containment system.

APPENDIX 5 of IGC Code - STANDARD FOR THE USE OF LIMIT STATE METHODOLOGIES IN THE DESIGN OF CARGO CONTAINMENT SYSTEMS OF NOVEL CONFIGURATION

1 General

1.1 The purpose of this standard is to provide procedures and relevant design parameters of limit state design of cargo containment systems of a novel configuration in accordance with section 4.27 of this Chapter.

1.2 Limit state design is a systematic approach where each structural element is evaluated with respect to possible failure modes related to the design conditions identified in section 4.3.4 of this Chapter. A limit state can be defined as a condition beyond which the structure, or part of a structure, no longer satisfies the requirements.

1.3 The limit states are divided into the three following categories:

> .1 Ultimate Limit States (ULS), which correspond to the maximum load-carrying capacity or, in some cases, to the maximum applicable strain, deformation or instability in structure resulting from buckling and plastic collapse; under intact (undamaged) conditions;
>
> .2 Fatigue Limit States (FLS), which correspond to degradation due to the effect of cyclic loading; and
>
> .3 Accident Limit States (ALS), which concern the ability of the structure to resist accident situations.

1.4 Part A through part D of Sec 4 of this Chapter is to be complied with as applicable depending on the cargo containment system concept.

2. Design format

2.1 The design format in this standard is based on a Load and Resistance Factor Design format. The fundamental principle of the Load and Resistance Factor Design format is to verify that design load effects, L_d , do not exceed design resistances,R_d , for any of the considered failure modes in any scenario:

$$\boldsymbol{L_d \leq R_d}$$

A design load F_{dk} is obtained by multiplying the characteristic load by a load factor relevant for the given load category:

$$F_{dk} = \gamma_f F_k$$

where:

γ_f is load factor; and

F_k is the characteristic load as specified in part B and part C of Section 4

A design load L_d (e.g. stresses, strains, displacements and vibrations) is the most unfavourable load effect derived from the design loads, and may be expressed by:

$$L_d = q\,(F_{d1}, F_{d2}, \dots . F_{dN})$$

Where q denoted the functional relationship between load and load effect determined by structural analyses.

The design resistance R_d is deermined as follows:

$$R_d = R_k / (\gamma_R\ \gamma_C)$$

Where:

R_k is the characteristic resistance. In case of materials covered by section 6, it may be, but not limited to, specified minimum yield stress, specified minimum tensile strength, plastic resistance of cross sections and ultimate buckling strength;

γ_R is the resistance factor defined as $\gamma_R = \gamma_m \gamma_s$

γ_m is the partial resistance factor to take account of the probabilistic distribution of the material properties (material factor);

γ_s is the partial resistance factor to take account of the uncertainties on the capacity of the structure, such as the quality of the construction, method considered for determination of the capacity including accuracy of analysis; and

$\boldsymbol{\gamma_C}$ is the consequence class factor, which accounts for the potential results of failure with regard to release of cargo and possible human injury.

2.2 Cargo containment design is to take into account potential failure consequences. Consequence classes are defined in table 1, to specify the consequences of failure when the mode of failure is related to the Ultimate Limit State, the Fatigue Limit State, or the Accident Limit State.

Table 1: Consequences classes

Consequence class	Definition
Low	Failure implies minor release of the cargo
Medium	Failure implies release of the cargo and potential for human injury
High	Failure implies significant release of the cargo and high potential for human injury/fatality

3 Required analyses

3.1 Three dimensional finite element analyses is to be carried out as an integrated model of the tank and the ship hull, including supports and keying system as applicable. All the failure modes shall be identified to avoid unexpected failures. Hydrodynamic analyses are to be carried out to determine the particular ship accelerations and motions in irregular waves, and the response of the ship and its cargo containment systems to these forces and motions.

3.2 Buckling strength analyses of cargo tanks subject to external pressure and other loads causing compressive stresses are to be carried out in accordance with recognized standards. The method is to adequately account for the difference in theoretical and actual buckling stress as a result of plate out of flatness, plate edge misalignment, straightness, ovality and deviation from true circular form over a specified arc or chord length, as relevant.

3.3 Fatigue and crack propagation analysis is to be carried out in accordance with paragraph 5.1 of this standard.

4 Ultimate Limit States

4.1 Structural resistance may be established by testing or by complete analysis taking account of both elastic and plastic material properties. Safety margins for ultimate strength are to be introduced by partial factors of safety taking account of the contribution of stochastic nature of loads and resistance (dynamic loads, pressure loads, gravity loads, material strength, and buckling capacities).

4.2 Appropriate combinations of permanent loads, functional loads and environmental loads including sloshing loads are to be considered in the analysis. At least two load combinations with partial load factors as given in table 2 are to be used for the assessment of the ultimate limit states.

Table 2 : Partial load factors

Load Combination	Permanent Loads	Functional Loads	Enviromental Loads
‘ a ‘	1.1	1.1	0.7
‘ b ‘	1.0	1.0	1.3

The load factors for permanent and functional loads in load combination '*a*' are relevant for the normally well-controlled and/or specified loads applicable to cargo containment systems such as vapour pressure, cargo weight, system self-weight, etc. Higher load factors may be relevant for permanent and functional loads where the inherent variability and/or uncertainties in the prediction models are higher.

4.3 For sloshing loads, depending on the reliability of the estimation method, a larger load factor may be required by IRS.

4.4 In cases where structural failure of the cargo containment system are considered to imply high potential for human injury and significant release of cargo, the consequence class factor shall be taken as $\gamma_C = 1.2$ This value may be reduced if it is justified through risk analysis and subject to the approval by IRS. The risk analysis is to take account of factors including, but not limited to, provision of full or partial secondary barrier to protect hull structure from the leakage and less hazards associated with intended cargo. Conversely, higher values may be fixed by the IRS, for example, for ships carrying more hazardous or higher pressure cargo. The consequence class factor is to in any case not be less than 1.0.

4.5 The load factors and the resistance factors used are to be such that the level of safety is equivalent to that of the cargo containment systems as described in sections 4.21 to 4.26 . This may be carried out by calibrating the factors against known successful designs.

4.6 The material factor γ_m is to in general reflect the statistical distribution of the mechanical properties of the material, and needs to be interpreted in combination with the specified characteristic mechanical properties. For the materials defined in section 6, the material factor γ_m may be taken as:

1.1 : when the characteristic mechanical properties specified by the recognized organization typically represents the lower 2.5% quantile in the statistical distribution of the mechanical properties; or

1.0 : when the characteristic mechanical properties specified by the recognized organization represents a sufficiently small quantile such that the probability of lower mechanical properties than specified is extremely low and can be neglected.

4.7 The partial resistance factors γ_{si} in general be established based on the uncertainties in the capacity of the structure considering construction tolerances, quality of construction, the accuracy of the analysis method applied, etc.

4.7.1 For design against excessive plastic deformation using the limit state criteria given in paragraph 4.8 of this standard, the partial resistance factors γ_{si} is to be taken as follows:

$$\gamma_{s1} = 0.76\frac{B}{k_1}$$

$$\gamma_{s1} = 0.76\frac{D}{k_1}$$

$$k_1 = Min\left(\frac{R_m}{R_e}\frac{B}{A};1\right)$$

$$k_2 = Min\left(\frac{R_m}{R_e}\frac{D}{C};1\right)$$

Factors A, B, C and D are defined in section 4.22.3.1. R_m and R_e are defined in section 4.18.1.3.

The partial resistance factors given above are the results of calibration to conventional type B independent tanks.

4.8 Design against excessive plastic deformation

4.8.1 Stress acceptance criteria given below refer to elastic stress analyses.

4.8.2 Parts of cargo containment systems where loads are primarily carried by membrane response in the structure are to satisfy the following limit state criteria:

$$\sigma_m \le f$$

$$\sigma_L \le 1.5f$$

$$\sigma_b \le 1.5F$$

$$\sigma_L + \sigma_b \le 1.5F$$

$$\sigma_m + \sigma_b \le 1.5F$$

$$\sigma_m + \sigma_b + \sigma_g \le 3F$$

$$\sigma_L + \sigma_b + \sigma_g \le 3F$$

Where:

σ_m=equivalent primary general membrane stress

σ_L=equivalent primary local membrane stress

σ_b=equivalent primary bending stress

σ_g=equivalent secondary stress

$$f = \frac{R_e}{\gamma_{s1}\,\gamma_m\,\gamma_C}$$

$$F = \frac{R_e}{\gamma_{s2}\,\gamma_m\,\gamma_C}$$

With regard to the stresses σ_m , σ_L , σ_b and σ_g , see also the definition of stress categories in section 4.28.3.

4.8.3 Parts of cargo containment systems where loads are primarily carried by bending of girders, stiffeners and plates, are to satisfy the following limit state criteria:

$$\sigma_{ms} + \sigma_{bp} \le 1.25F \quad (note\ 1\ and\ 2)$$

$$\sigma_{ms} + \sigma_{bp} + \sigma_{bs} \le 1.25F \quad (note\ 2)$$

$$\sigma_{ms} + \sigma_{bp} + \sigma_{bs} + \sigma_{bt} + \sigma_g \le 3F$$

Note 1: The sum of equivalent section membrane stress and equivalent membrane stress in primary structure ($\sigma_{ms} + \sigma_{bp}$) will normally be directly available from three-dimensional finite element analyses.

Note 2: The coefficient, 1.25, may be modified by IRS considering the design concept, configuration of the structure, and the methodology used for calculation of stresses.

Where:

σ_{ms}= equivalent section membrane stress in primary structure

σ_{bp}= equivalent membrane stress in primary structure and stress in secondary and tertiary structure caused by bending of primary structure

σ_{bs}= section bending stress in secondary structure and stress in tertiary structure caused by bending of secondary structure

σ_{bt}= section bending stress in tertiary structure

σ_g= equivalent secondary stress

$$f = \frac{R_e}{\gamma_{s1}\ \gamma_m\ \gamma_C}$$

$$F = \frac{R_e}{\gamma_{s2}\ \gamma_m\ \gamma_C}$$

The stresses σ_{ms} , σ_{bp} , σ_{bs} and σ_{bt} , are defined in 4.8.4. For a definition of σ_g , see section 4.28.3.

Skin plates are to be designed in accordance with the requirements of IRS. When membrane stress is significant, the effect of the membrane stress on the plate bending capacity is to be appropriately considered in addition.

4.8.4 Section stress categories

Normal stress is the component of stress normal to the plane of reference.

Equivalent section membrane stress is the component of the normal stress that is uniformly distributed and equal to the average value of the stress across the cross section of the structure under consideration. If this is a simple shell section, the section membrane stress is identical to the membrane stress defined in paragraph 4.8.2 of this standard.

Section bending stress is the component of the normal stress that is linearly distributed over a structural section exposed to bending action, as illustrated in Fig.1.

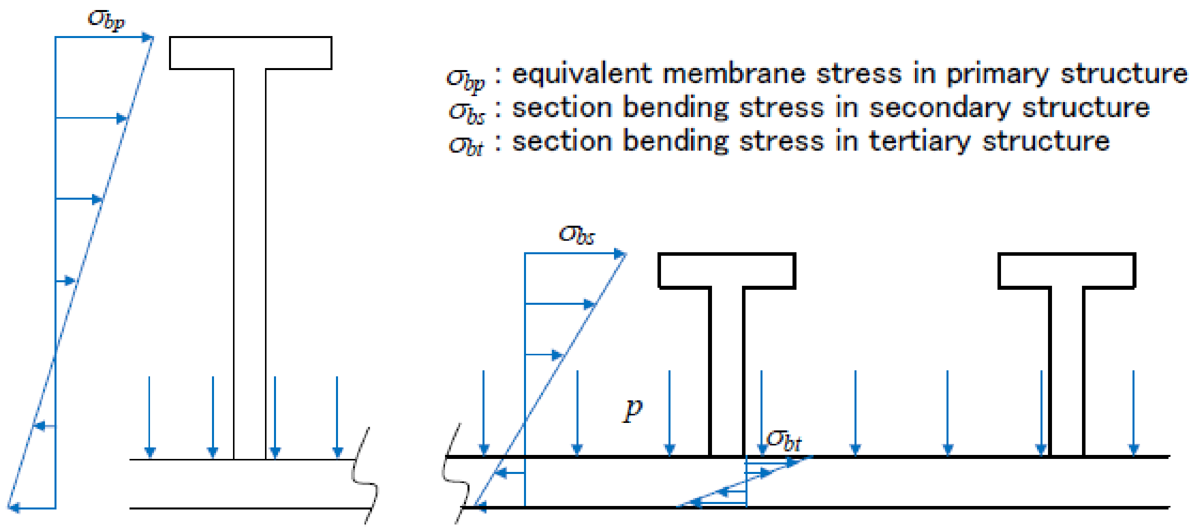


Figure 1: Definition of the three categories of section stress (Stresses σ_{bp} and σ_{bs} are normal to the cross section shown.)

4.9 The same factors γ_C, γ_m, γ_{si} are to be used for design against buckling unless otherwise stated in the applied recognized buckling standard. In any case the overall level of safety is not to be less than given by these factors.

5 Fatigue Limit States

5.1 Fatigue design condition as described in section 4.18.2 is to be complied with as applicable depending on the cargo containment system concept. Fatigue analysis is required for the cargo containment system designed under section 4.27 and this annexure.

5.2 The load factors for FLS shall be taken as 1.0 for all load categories.

5.3 Consequence class factor γ_C and resistance factor γ_R are to be taken as 1.0.

5.4 Fatigue damage is to be calculated as described in sections 4.18.2.2 to 4.18.2.5 The calculated cumulative fatigue damage ratio for the cargo containment systems are to be less than or equal to the values given in table 3.

Table 3 : Maximum allowable cumulative fatigue damage ratio			
	Consequence Class		
C_W	Low	Medium	High
	1	0.5	0.5 (Note 1)
Note 1: Lower value are to be used in accordance with sections 4.18.2.7 to 4.18.2.9 , depending on the detectability of defect or crack, etc.			

5.5 Lower values may be fixed by IRS, for example for tank structures where effective detection of defect or crack cannot be assured, and for ships carrying more hazardous cargo.

5.6 Crack propagation analyses are required in accordance with sections 4.18.2.6 to 4.18.2.9 The analysis is to be carried out in accordance with methods laid down in a standard recognized by IRS.

6 Accident Limit States

6.1 Accident design condition as described in section 4.18.3 is to be complied with as applicable, depending on the cargo containment system concept.

6.2 Load and resistance factors may be relaxed compared to the ultimate limit state considering that damages and deformations can be accepted as long as this does not escalate the accident scenario.

6.3 The load factors for ALS are to be taken as 1.0 for permanent loads, functional loads and environmental loads.

6.4 Loads mentioned in section 4.13.9 (Static heel loads) and section 4.15 (Collision and Loads due to flooding on ship) need not be combined with each other or with environmental loads, as defined in section 4.14.

6.5 Resistance factor γ_R is to in general be taken as 1.0.

6.6 Consequence class factors γ_C are to be in general be taken as defined in paragraph 4.4 , but may be relaxed considering the nature of the accident scenario.

6.7 The characteristic resistance R_k is to in general be taken as for the ultimate limit state, but may be relaxed considering the nature of the accident scenario.

6.8 Additional relevant accident scenarios are to be determined based on a risk analysis.

7 Testing

7.1 Cargo containment systems designed according to this standard is to be tested to the same extent as described in section 4.20.3 , as applicable depending on the cargo containment system concept.

End of Chapter

Chapter 5

Container Ships

Contents

Section

Section 1

General

1.1 Application

1.1.1 The requirements of this chapter apply to container ships and are supplementary to those given for the assignment of main characters of class.

1.1.2 Vessels built in compliance with the above requirements will be eligible to be assigned the class notation "**CONTAINER SHIP**".

1.1.3 Container ships are seagoing ships of single or double skin side construction, designed exclusively for the carriage of standard general cargo freight containers on holds and on deck.

1.1.4 When oil or dangerous goods are intended to be carried in limited quantities inside the containers, the safety aspects will be specially considered.

1.2 Documentation

1.2.1 In addition to the information and plans required by Pt.3, Ch.1, Sec.3, the following are to be submitted:

- Hull section modulus calculations about vertical and horizontal axes at sufficient number of sections, distributed over the length of the ship so as to include sections where abrupt structural changes are present.

- Combined stress distribution and envelope of still water bending moments in graphical or tabular forms.

- Outline plan showing stowage arrangement of containers.

- Plans showing details of cell guides and supporting structure; and their attachment to main structural members.

- Details of reinforcement to structure in way of container corners.

1.2.2 A copy of the Cargo Securing Manual approved by the National Administration is to be submitted for reference.

1.3 Materials and protection

1.3.1 Materials and grades of steel are to comply with the requirements of Pt.3, Ch.2. The material grades of steel are generally to be maintained over the entire region of the container holds.

1.3.2 Steels used for container supporting structures and fixed fittings welded to the ship are in general to comply with the requirements of Pt.2. Other steels and materials may also be specially considered.

Section 2

Usage of extremely thick plates of high strength steels

2.1 General

2.1.1 The requirements in this section are applicable in case of container ships using high strength steel plates of grade; EH36, EH40, EH47 of thicknesses over 50[mm] and not exceeding 100[mm] for longitudinal structural members.

Note 1: EH36 EH40 and EH47 means steel plates having minimum specified yield points of 355, 390 and 460 [N/mm^2], respectively.

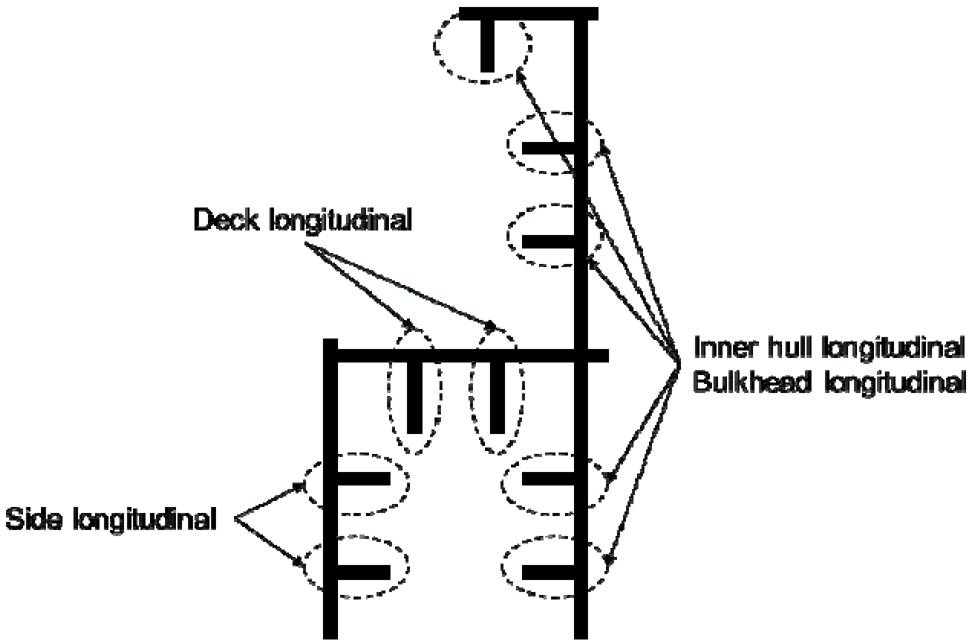


Fig.2.3.2.2 : Upper flange longitudinal structural members

2.1.2 Measures for preventing brittle fracture of longitudinal members are given in 2.3 and Table 2.3.1.
For steel plates with thicknesses exceeding 100[mm] appropriate measures acceptable to IRS are to be taken to prevent brittle crack initiation and propagation.

2.2 Hull Structural Design Requirements for EH47 Grade Steel

2.2.1 The material factor k, defined in Pt.3 Ch.2 1.2.2 is to be taken as 0.62.

2.2.2 Fatigue assessment is also to be performed on longitudinal structural members to the satisfaction of IRS.

2.2.3 Details of construction of structural members such as connections between outfitting and hull structures are to be specially approved.

2.3 Measures to prevent brittle fracture

2.3.1 The thickness and the yield strength shown in the Table 2.3.1 apply to the hatch coaming structure, and are the controlling parameters for the application of countermeasures for longitudinal members.

If the as built thickness of the hatch coaming structure is below the values contained in the table, countermeasures are not necessary regardless of the thickness and the yield strength of the upper deck.

2.3.2 NDT during construction (Measure No. 1 of Table 2.3.1):

2.3.2.1 NDT other than visual inspection on all target block joints is to be carried out as per 2.3.2. Enhanced NDT as specified in 2.3.4.3 is to be carried out in accordance with the appropriate standard.

2.3.2.2 General

Ultrasonic testing (UT) is to be carried out to the satisfaction of IRS, on all block-to-block butt joints of all the upper flange longitudinal structural members in the cargo hold region. Upper flange longitudinal structural members include the topmost strakes of the inner hull/bulkhead, the sheer strake, main deck, coaming plate, coaming top plate, and all attached longitudinal stiffeners (See Fig 2.3.2.2).

2.3.2.3 Acceptance Criteria of UT
Acceptance criteria of UT are to be acceptable to IRS.

Table 2.3.1 : Measures to prevent Brittle Fracture

Yield Strength [N/mm^2]	Thickness (mm)	Option	Measures			
			1	2	3+4	5
355	50<t≤85		-.	-.	-.	-.
	85<t≤100		X	-.	-.	-.
390	50<t≤85		X	-.	-.	-.
	85<t≤100	A	X	-.	X	X
		B	X*	-.**	-.	X
460 (FCAW)	50<t≤100	A	X	-.	X	X
		B	X*	-.**	-.	X
460 (EGW)	50<t≤100		X	-.	X	X

Measures:

1: NDT other than visual inspection on all target block joints (during construction). See 2.3.2

2: Periodic NDT other than visual inspection on all target block joints (after delivery). See 2.3.3

3: Brittle crack arrest design against straight propagation of brittle crack along the weld line to be taken (during construction). See 2.3.4.3.1 i, ii or iii.

4: Brittle Crack arrest design against deviation of brittle crack from weld line (during construction). See 2.3.4.3.2

5: Brittle crack arrest design against propagation of cracks from other weld areas such as fillets and attachment welds (during construction). See 2.3.4.3.

Symbols:

a. “X” means “To be applied”.
b. “-.” means “Need not be applied”
c. A, B under the column titled “options” means option “A” or “B” may be selected.

Note:
*: See 2.3.4.3.1 iv.
**: May be required at the discretion of IRS.

2.3.3 Periodic NDT after delivery (Measure No.2 of Table 2.3.1):

2.3.3.1 General

The procedure of the NDT is to be acceptable to IRS.

2.3.3.2 Timing of Ultrasonic Testing (UT)

Where UT is carried out, the frequency of survey is to acceptable to IRS

2.3.3.3 Acceptance Criteria of UT

Where UT is carried out, acceptance criteria of UT are to be acceptable to IRS.

2.3.4 Brittle crack Arrest Design (Measure No 3, 4 and 5 of Table 2.3.1)

2.3.4.1 General

2.3.4.1.1 Measures for prevention of brittle crack propagation, which is the same meaning as Brittle crack arrest design, are to be taken within the cargo hold region.

2.3.4.1.2 The approach given in this section generally applies to the block-to-block joints but it should be noted that cracks can initiate and propagate away from such joints. Therefore, appropriate measures should be considered in accordance with 2.3.4.2.1 b)(I).

2.3.4.1.3 Brittle crack arrest steel is defined as steel plate with measured crack arrest properties, K_{ca} at -10^oC ≥ 6,000 [N/mm$^{3/2}$] or other methods based on determination of crack arrest temperature (CAT).

Note:

- The detailed design arrangements are to be submitted for approval by IRS. Measures other than the ones given above may also be considered and accepted for review by IRS.
- K_{ca} is determined based on the standard ESSO test (See Pt2. Ch2. Sec5.) or other alternative method. CAT maybe determined by the double tension wide plate test or equivalent. The use of Nil Ductility Test Temperature (NDTT) may be considered provided mathematical relationships of NDTT to K_{ca} or CAT can be shown.
- Where the thickness of the steel exceeds 80 [mm] the required K_{ca} value or alternative crack arrest parameter for the brittle crack arrest steel plate is to be specifically agreed with IRS.

2.3.4.2 Functional Requirements of brittle crack arrest design

2.3.4.2.1 The purpose of the brittle crack arrest design is aimed at arresting propagation of a crack at a proper position and to prevent large scale fracture of the hull girder.

a) The point of a brittle crack initiation is to be considered in the block-to-block butt joints both of hatch side coaming and upper deck.

b) Both of the following cases are to be considered:

   I. where the brittle crack runs straight along the butt joint, and
   II. where the brittle crack initiates or deviates away from the butt joint and runs into base metal.

2.3.4.3 Concept examples of brittle crack arrest design

The following are considered to be acceptable examples of brittle crack arrest-design. The detail design arrangements are to be submitted for approval to IRS. Other concept designs may be considered and accepted for review by IRS.

2.3.4.3.1 Brittle crack arrest design for 2.3.4.2.1 (b)(I)

i. Where the block-to-block butt welds of the hatch side coaming and those of the upper deck are shifted, this shift is to be at least 300 [mm]. Brittle crack arrest steel is to be provided for the hatch side coaming.
ii. Where crack arrest holes are provided in way of the block-to-block butt welds at the region where hatch side coaming weld meets the deck weld, the fatigue strength of the lower end of the butt weld is to be assessed. Additional countermeasures are to be taken for the possibility that a running brittle crack may deviate from the weld line into the upper deck or the hatch side coaming. These countermeasures are to include the application of brittle crack arrest steel in the hatch side coaming.
iii. Where the Insert plates of brittle crack arrest steel or weld metal inserts with high crack arrest toughness properties are provided in way of the block-to-block butt welds at the region where the hatch side coaming weld meets the deck weld,

additional countermeasures are to be taken for the possibility that a running brittle crack may deviate from the weld line into upper deck or the hatch side coaming. These countermeasures are to include the application of brittle crack arrest steel in hatch side coamings.

iv. The application of enhanced NDT particularly Time of Flight Diffraction (TOFD) technique using stricter defect acceptance in lieu of standard UT technique specified in 2.3.2 can be an alternative to (i) to (iii) mentioned above.

Brittle crack arrest design for 2.3.4.2.1 (b)(II):

- Brittle crack arresting steel is to be used for the upper deck along the cargo hold region in a way suitable to arrest a brittle crack initiating from the coaming and propagating into the structure below.

Measures to arrest propagation of cracks from other weld areas such as fillets and attachment welds during construction are identical to the ones mentioned above.

Section 3

Ship Arrangement

3.1 General

3.1.1 Container ships are in general to be provided with closed hatches with weathertight means of closure.

3.1.2 Proposals for omission of hatch covers altogether will be specially considered, generally in accordance with MSC/Circ.608, "Interim Guidelines for Open-top Containerships" issued by IMO. The proposals will also require to be agreed by the National Statutory Authority in order to obtain an exemption from the requirement of hatch covers for the assignment of loadline.

3.2 Non-weathertight hatch covers above superstructure deck

3.2.1 Non-weathertight hatch covers may be accepted above a level equivalent to second tier superstructure; or above a level equivalent to third tier superstructure in the forward quarter of the ship's length; subject to the approval of the flag Administration and satisfying the requirements given in 3.2.2 to 3.2.10.

3.2.2 These covers would be accepted only on containerships.

3.2.3 They may be fitted to hatchways located on weatherdecks which are at least two standard superstructure heights above an actual freeboard deck or an assumed freeboard deck from which a freeboard can be calculated which will result in a draught not less than that corresponding to the freeboard actually assigned. Where any part of a hatchway is forward of a point located one quarter of the ship's length (0.25L) from the forward perpendicular, that hatchway is to be located on a weatherdeck at least three standard superstructure heights above the actual or assumed freeboard deck. It is to be noted that the assumed freeboard deck is used only for the purpose of measuring the height of the deck on which the hatchways are situated and may be an imaginary, or virtual deck and in this case is not to be used for the actual assignment of freeboard. The vessels freeboard is to be assigned from an actual deck, designated as the freeboard deck, which is to be determined in accordance with the International Loadline Convention.

3.2.4 The hatchway coaming is to be not less than 600 [mm] in height.

3.2.5 The non-weathertight gaps between hatch cover panels are to be considered as unprotected openings with respect to the requirements of intact and damage stability calculations. They are to be as small as possible commensurate with the capacity of the bilge system and expected water ingress and the capacity and operational effectiveness of the fire-fighting system and generally, not to exceed 50 [mm].

3.2.6 Labyrinths, gutter bars, or equivalents are to be fitted proximate to the edges of each panel in way of the gaps to minimise the amount of water that can enter the container hold from the top surface of each panel.

3.2.7 Scantlings of the hatch cover panels as well as details on the securing arrangements to the vessel's support structure and coamings are to be equivalent to those for weathertight covers.

3.2.8 If a fixed gas fire extinguishing system is fitted in the hold, the capacity of the system is to be increased by 10 percent over that for the same vessel with weathertight hatch covers, provided the gap between hatches is not more than 50 [mm]. Alternatively, a fixed water spray system is to be provided.

3.2.9 The bilge system required for cargo holds with non-weathertight hatches is to have sufficient additional capacity for water ingress based on the greater of:

i) a steady rainfall of 100 [mm/hr] applied through the total area of the gaps between panels; or

ii) the capacity of the fire fighting water spray system where fitted.

The size of the bilge main is to be in accordance with the increased bilge pump capacity. Bilge alarms are to be provided in each hold fitted with non-weathertight covers.

3.2.10 Container holds fitted with non-weathertight hatch covers on vessels intended to carry dangerous goods are to be considered in the same manner as open-top container holds according to 3.1.2.

3.3 Ships with large hatch openings

3.3.1 A ship is to be considered to have large hatch openings if any one of the following conditions are met (See Fig.3.3.1):

a) $\dfrac{b}{B_1} \geq 0.7$

b) $\dfrac{l_H}{l_{BH}} \geq 0.89$

c) $\dfrac{b}{B_1} \geq 0.6$ and $\dfrac{l_H}{l_{BH}} > 0.7$

where,

b = breadth [m], of the opening. Where there are multiple openings abreast, these are regarded as a single opening, and b is to be the sum of individual widths of these openings.

l_{BH} =distance [m], between centres of the deck strip at each end of the opening. Where there is no further opening beyond the one under consideration, the point to which is measured will be specially considered.

l_H = length of the opening [m].

B_1 = extreme breadth of deck including opening, measured at the mid-length of the opening [m].

3.3.2 The structural configuration of these ships are to provide for adequate torsional rigidity in the form of either a double skin side construction or a single skin side shell with efficient torsion box girders or equivalent structures at the top sides.

The double skin or the torsion box is to extend over the entire cargo hold area and efficiently scarphed at the ends.

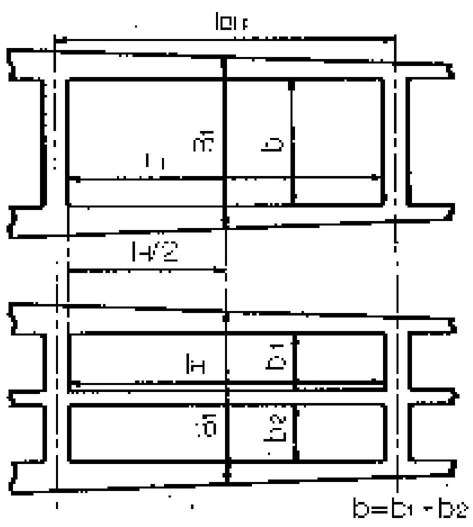


Fig.3.3.1 : Hatch opening dimensions

Section 4

Hull Girder Strength

4.1 General

4.1.1 Ships of L > 90 [m] are to be longitudinally framed at topsides and at bottom. Side shell clear of the torsion box may be longitudinally or transversely framed.

4.2 Application

4.2.1 The requirements in this section are applicable to steel ships with a length L of 90 [m] and greater and operated in unrestricted service:

- Container Ships
- Ships dedicated primarily to carry their load in containers

4.2.2 Wave induced load requirements specified in this section apply to monohull displacement ships in unrestricted service and are limited to ships meeting the following criteria:

.1 length of ship: 90 [m] ≤ L ≤ 500 [m]

.2 Proportion : 5≤L/B≤9, 2≤B/T≤6

.3 Block coefficient at scantling draft : 0.55 ≤ C_B ≤ 0.9

4.2.3 For ships that do not meet all of the criteria specified in 4.2.2, applied wave induced loads is to be obtained from direct analysis method.

4.2.4 For ships of length 150 [m] or above, a finite element analysis is to be carried out (Refer to Sec 7) in addition to the requirements of this section.

4.2.4 Longitudinal extent of strength assessment

4.2.4.1 The stiffness, yield strength, buckling strength and hull girder ultimate strength assessment are to be carried out in way of 0.2L to 0.75L with due consideration given to locations where there are significant changes in hull cross section, e.g. changing of framing system and the fore and aft end of the forward bridge block in case of two-island designs.

4.2.4.2 In addition, strength assessments are to be carried, out outside areas mentioned in 4.2.4.1, by the method deemed necessary by IRS. As a minimum assessments are to be carried out at forward end of the foremost cargo hold and the aft end of the aft most cargo hold.

4.3 Corrosion margin and net thickness

4.3.1 Net scantling definitions

4.3.1.1 The strength is to be assessed using the net thickness approach on all scantlings.

4.3.1.2 The net thickness for the plates, webs and flanges is obtained by subtracting the voluntary addition and the factored corrosion addition from the as built thickness, as follows

$$t_{net} = t_{as\_built} - t_{vol\_add} - \alpha t_c$$

Where,

t_{net}:net thickness [mm]

t_{as_built}: as built thickness [mm]

t_{vol_add}: voluntary addition [mm]

t_c: corrosion addition, in [mm]

α: corrosion addition factor

Voluntary addition, if being used, is to be clearly indicated on the drawings.

Structural requirement	Property/analysis type	α
Strength assessment	Section properties	0.5
Buckling strength	Section propertied (stress determination)	0.5
	Buckling capacity	1
Hull girder ultimate strength	Section properties	0.5
	Buckling/collapse capacity	0.5

4.3.2 Determination of corrosion addition

4.3.2.1 The corrosion addition for each of the two sides of a structural member, t_{c1} or t_{c2} is specified in table. The total corrosion addition t_c, [mm], for both sides of the structural member is obtained by the following formula:

$$t_c = (t_{c1} + t_{c2}) + t_{res}$$

4.3.2.2 For an internal member within a given compartment, the total corrosion addition, t_c is obtained from the following formula:

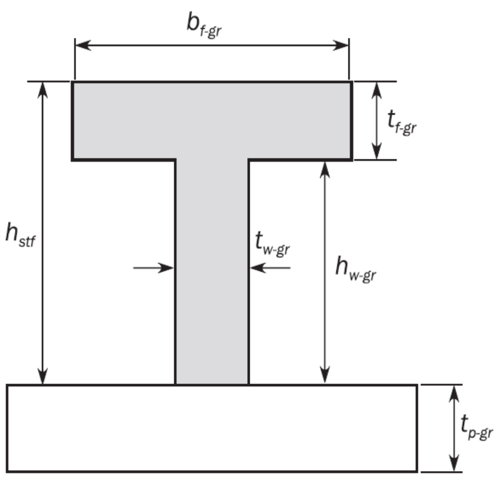
$$t_c = (2t_{c1}) + t_{res}$$

4.3.2.3 The corrosion addition of a stiffener is to be determined according to the location of its connection to the attached plating.

Corrosion addition for one side of the structural member	
Compartment type	**One side corrosion addition t_{c1} or t_{c2} [mm]**
Exposed to sea water	1
Exposed to atmosphere	1
Ballast water tank	1
Void and dry spaces	0.5
Fresh water, fuel oil and lube oil tank	0.5
Accommodation spaces	0
Container holds	1
Compartment types not mentioned above	0.5

4.3.3 Determination of net section properties

4.3.3.1 The net section modulus, moment of inertia and shear area properties of a supporting member are to be calculated using net dimensions of the attached plate, web and flange, as defined in Fig.4.3.3.1. The net cross-sectional area, the moment of inertia about axis parallel to the attached plate and the associated neutral axis position are to be determined through applying a corrosion magnitude of $0.5\alpha t_c$ deducted from the surface of the profile cross-section.



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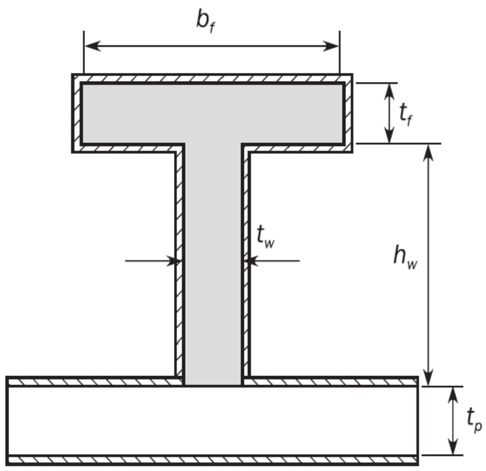


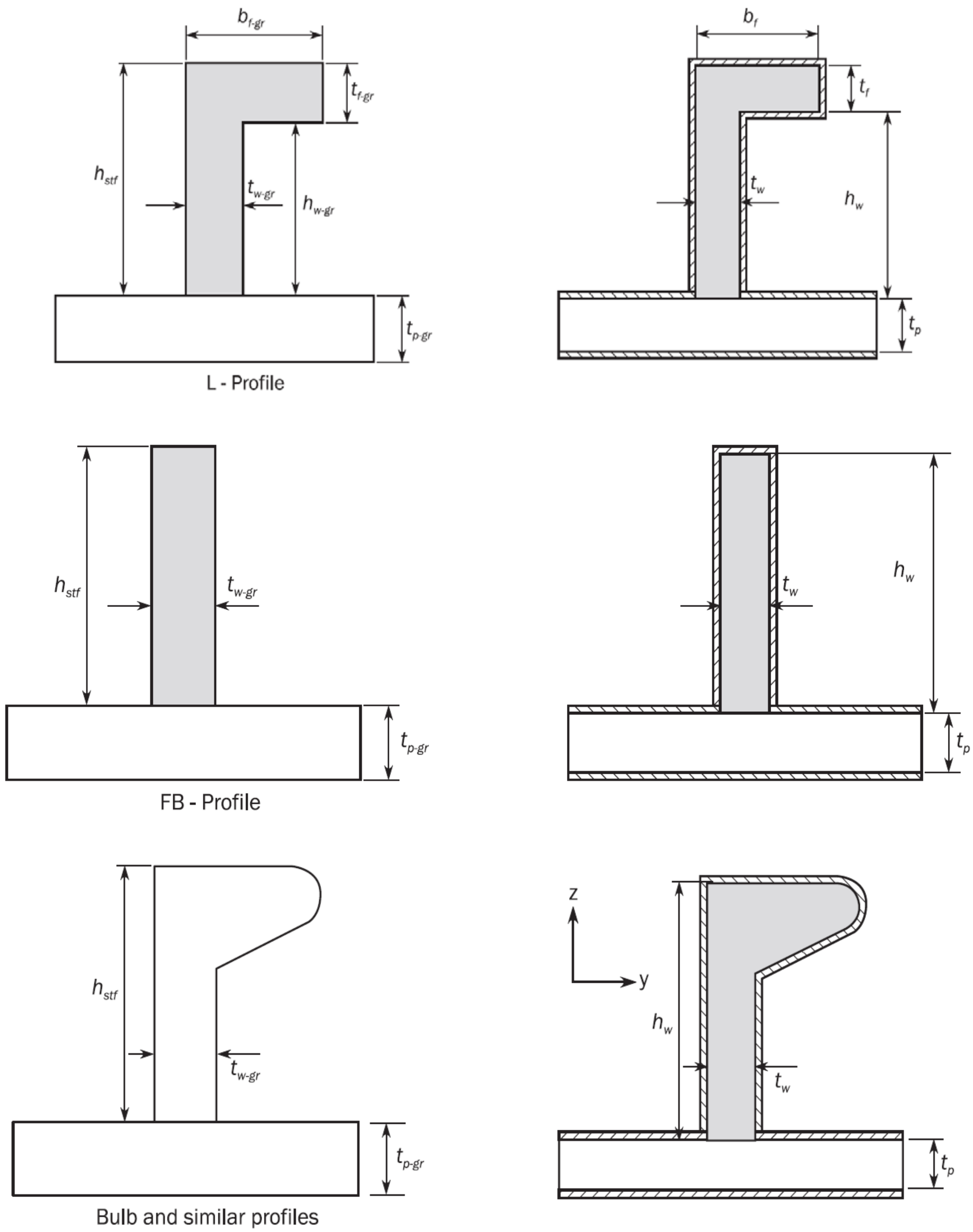


Fig.4.3.3.1 : Net sectional properties of supporting members

4.4 Loads

4.4.1 Still water bending moments, *Ms* [kNm], and shear forces *Fs* [kN] are to be calculated at each section along the ship length for the design loading conditions

4.4.2 In general, the design cargo and ballast loading conditions, based on amount of bunker, fresh water and stores at departure and arrival, are to be considered for the *Ms* and *Fs* calculations.

4.4.3 Where the amount and disposition of consumables at any intermediate stage of the voyage are considered more severe, calculations for such intermediate conditions are to be submitted in addition to those for departure and arrival conditions.

4.4.4 Where any ballasting and/or de-ballasting is intended during voyage, calculations of the intermediate condition just before and just after ballasting and/or de-ballasting any ballast tank are to be submitted and where approved included in the loading manual for guidance.

4.4.5 The permissible vertical still water bending moments M_{Smax} and M_{Smin} and the permissible vertical still water shear forces F_{Smax} and F_{Smin} in seagoing conditions at any longitudinal position are to envelop:

.1 The maximum and minimum still water bending moments and shear forces for the seagoing loading conditions defined in the Loading Manual.

.2 The maximum and minimum still water bending moments and shear forces specified by the designer

4.4.6 The Loading Manual is to include the relevant loading conditions, which envelop the still water hull girder loads for seagoing conditions, including following loading conditions:

.1 The design loading and ballast conditions, subdivided into departure and arrival conditions, and ballast exchange at sea conditions, where applicable, upon which the approval of the hull scantlings is based.

.2 Homogeneous loading conditions at maximum draught

.3 Ballast conditions

.4 Special loading conditions, e.g. container or light load conditions at less than the maximum draught, heavy cargo, empty holds or non-homogeneous cargo conditions deck cargo conditions, etc., where applicable

.5 Short voyage or harbour conditions, where applicable

.6 Docking condition afloat

.7 Loading and unloading transitory conditions, where applicable

4.4.7 The distribution of the vertical wave induced bending moments, M_w [kNm], along the ship length is given in Fig.4.4.7 a) where:

$$M_{W-Hog} = +1.5 f_R L^3 C C_W \left(\frac{B}{L}\right)^{0.8} f_{NL-Hog}$$

$$M_{W-Sag} = -1.5 f_R L^3 C C_W \left(\frac{B}{L}\right)^{0.8} f_{NL-Sag}$$

f_R : Factor related to the operational profile, to be taken as 0.85

f_{NL-Hog} : Non-linear correction for hogging, to be taken as

$$f_{NL-Hog} = 0.3 \frac{C_B}{C_W} \sqrt{T}$$

Not to be taken greater than 1.1

f_{NL-Sag} : Non-linear correction for sagging, to be taken as

$$f_{NL-Sag} = 4.5 \frac{1 + 0.2 f_{Bow}}{C_W \sqrt{C_B}\ L^{0.3}}$$

Not to be taken greater than 1

f_{Bow}: Bow flare shape coefficient, to be taken as:

$$f_{Bow} = \frac{A_{DK} - A_{WL}}{0.2 L Z_f}$$

A_{DK}:Projected area in horizontal plane of uppermost deck [m^2] including the forecastle deck, if any, extending from 0.8L forward (see Fig.4.4.7 b)). Any other structures, e.g. plated bulwark, are to be excluded.

A_{WL}:Waterplane area, in [m^2] at draught T, extending from 0.8L forward.

Z_f:Vertical distance [m], from the waterline at draught T to the uppermost deck (or fore castle deck), measured at fore end (see Fig.4.4.7 b)), Any other structures, e.g plated bulwark, are to be excluded.

C: wave parameter, to be taken as:

$$C = 1 - 1.5\left(1 - \sqrt{\frac{L}{L_{ref}}}\right)^{2.2} \quad for\ L \le L_{ref}$$

$$C = 1 - 0.45\left(\sqrt{\frac{L}{L_{ref}}} - 1\right)^{1.7} \quad for\ L > L_{ref}$$

L_{ref}: Reference length [m], to be taken as:

$$L_{ref} = 315 C_W^{-1.3}$$

C_W: waterplane coefficient at the designed maximum load draught, to be taken as:

$$C_W = \frac{A_W}{L\,B}$$

A_W: waterplane area at the scantling draught

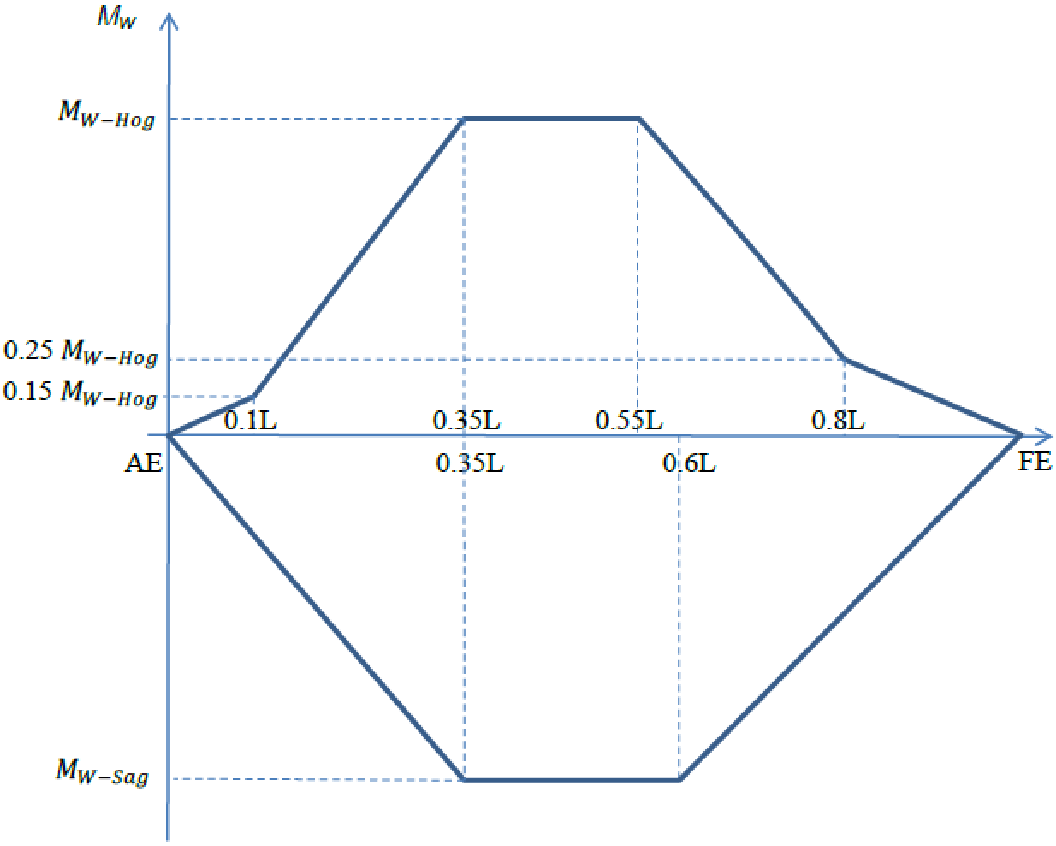


Fig.4.4.7 a) : Distribution of vertical wave bending moment along the ship length

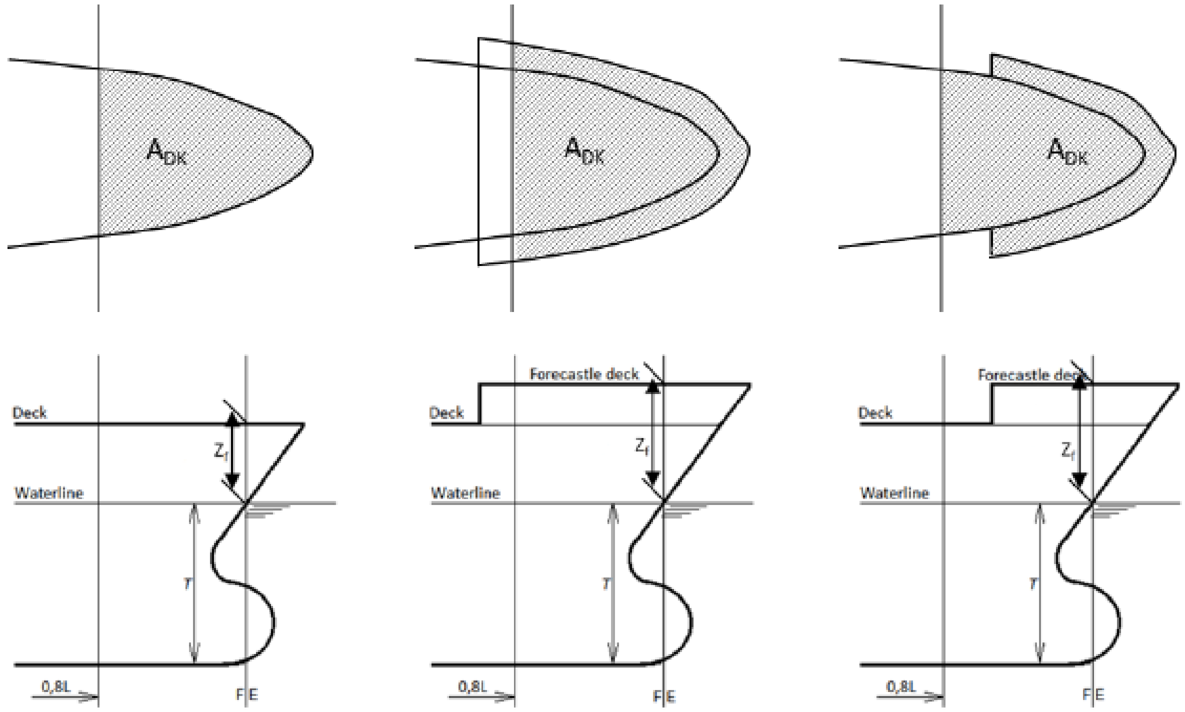


Fig.4.4.7 b) : Projected area A_{DK} and Vertical distance Z_f

4.4.8 The distribution of the vertical wave induced shear forces F_W (kN) along the ship length is given in Fig.4.4.8 are to be obtained using the following formulae:

$$F_{W-Hog-Aft} = +5.2 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} (0.3 + 0.7\, f_{NL-Hog})$$

$$F_{W-Hog-Fore} = -5.2 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} f_{NL-Hog}$$

$$F_{W-Sag-Aft} = -5.2 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} (0.3 + 0.7\, f_{NL-Sag})$$

$$F_{W-Sag-Fore} = +5.7 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} (0.25 + 0.75\, f_{NL-Sag})$$

$$F_{W-Mid} = +4 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8}$$

Where,

L_{ref}: Reference length [m], to be taken as:

$$L_{ref} = 330 C_W^{-1.3}$$

Other parameters in the above equations are to be taken in accordance with 4.4.7

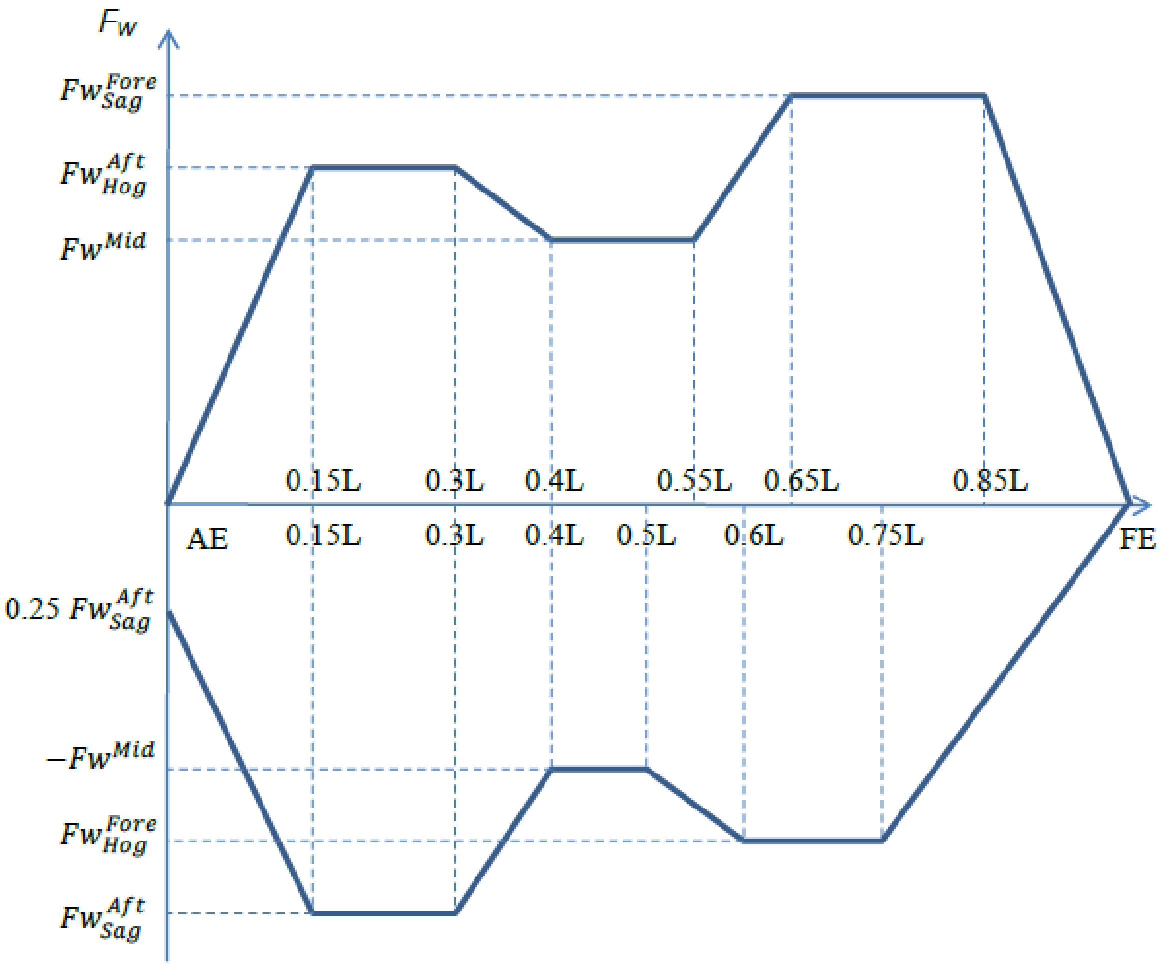


Fig.4.4.8 : Distribution of vertical wave shear force along the ship length

4.4.9 For strength assessments, the maximum hogging and sagging load cases given in Table 4.4.9 are to be checked. For each load case, the still water condition at each section, as defined in 4.4.1 to 4.4.6, is to be combined with the wave condition, as defined in 4.4.7 and 4.4.8.

Table 4.4.9 : Combination of still water bending moment and shear forces

Load Cases	**Bending moment**		**Shear Forces**	
	M_S	***M_W***	***F_S***	***F_W***
Hogging	M_{Smax}	M_{WH}	F_{Smax} for x ≤ 0.5L	F_{Wmax} for x ≤ 0.5L
			F_{Smin} for x > 0.5L	F_{Wmin} for x > 0.5L
Sagging	M_{Smin}	M_{WS}	F_{Smin} for x ≤ 0.5L	F_{Wmin} for x ≤ 0.5L
			F_{Smax} for x > 0.5L	F_{Wmax} for x > 0.5L

M_{WH}: Wave bending moment in hogging at the cross section under consideration, to be taken as the positive value of M_W as defined Fig.4.4.7 a)

M_{WS}: Wave bending moment is sagging at the cross section under consideration, to be taken as the negative value of M_W as defined in Fig.4.4.7 a)

F_{Wmax} : Maximum value of the wave shear force at the cross section under consideration, to be taken as the positive value of F_W as defined in Fig.4.4.8

F_{Wmin} : Minimum value of the wave shear force at the cross section under consideration, to be taken as the negative value of F_W as defined in Fig.4.4.8

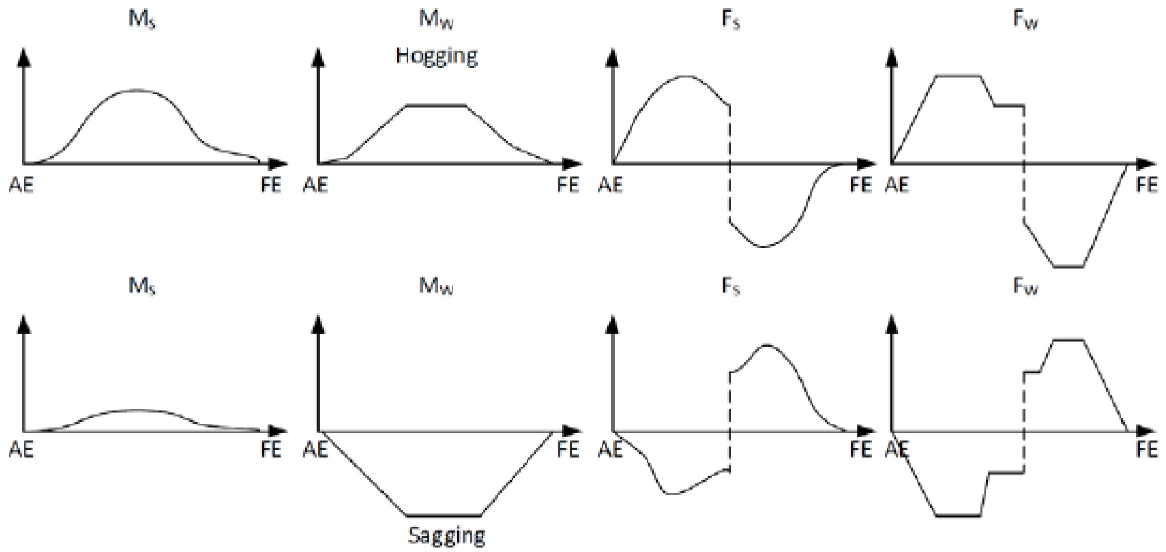


Fig.4.4.9 : Load combination to determine the maximum hogging and sagging load cases as given in Table 4.4.9

4.5 Hull girder stress

4.5.1 The hull girder bending stress and hull girder shear stress are to be determined at the load calculation point under consideration, for the “hogging” and “sagging” load cases as follows:

.1 Hull girder bending stress

$$\sigma_{HG} = \frac{\gamma_S M_S + \gamma_W M_W}{I_{net}}(Z - Z_n)10^{-3}$$

.2 Hull girder shear stress

$$\tau_{HG} = \frac{\gamma_S F_S + \gamma_W F_W}{t_{net}/q_v}10^{3}$$

γ_S, γ_W: Partial safety factors, to be taken as 1.

4.6 Strength assessment

4.6.1 General

4.6.1.1 Continuity of structure is to be maintained throughout the length of the ship. Where significant changes in structural occur adequate transitional structure is to be provided.

4.6.2 Stiffness assessment

4.6.2.1 The moment of inertia (in [m^4]) is to be in accordance with the formula:

$$I \geq 1.55L|M_S + M_W|10^{-7}$$

4.6.3 Yield strength assessment

4.6.3.1 For each of the load cases “hogging” and “sagging” the equivalent hull girder stress is to be in accordance with the formula :

$$\sigma_{eq} < \sigma_{perm}$$

$$\sigma_{eq} = \sqrt{\sigma_x^2 + 3\tau^2}$$

$$\sigma_{Perm} = \frac{R_{eH}}{\gamma_1 \gamma_2}$$

γ_1:Partial safety factor for material, to taken as

$$\gamma_1 = k\frac{R_{eH}}{235}$$

γ_2:Partial safety factor for load combinations and permissible stress, to be taken as:

γ_2= 1.24, for bending strength assessment according to 4.6.3.2

γ_2= 1.13, for shear stress assessment according to 4.3.3.3

4.6.3.2 The assessment of the bending stresses is to be carried out according to 4.6.3.1 at the following locations of the cross section:

- at bottom
- at deck
- at top of the hatch coaming
- at any point where there is a change of steel yield strength.

The following combination of hull girder stress as defined in 4.5 is to be considered:

$$\sigma_x = \sigma_{HG}$$

$$\tau = 0$$

4.6.3.3 The assessment of shear stress is to be carried out according to 4.6.3.1 for all structural elements that contribute to the shear strength capability. The following combination of hull girder stress as defined in 4.5 is to be considered:

$$\sigma_x = 0$$

$$\tau = \tau_{HG}$$

4.6.4 Buckling assessment

4.6.4.1 The requirements of 4.6.4 apply to plate panels and longitudinal stiffeners subject to hull girder bending and shear stress.

4.6.4.2 Acceptance criteria for the buckling assessment is defined as follows:

$$\eta_{act} \leq 1$$

4.6.4.3 The utilization factor, η_{act}, is defined as the inverse of the stress multiplication factor at failure γ_c , see Fig.4.6.4.1

$$\eta_{act} = \frac{1}{\gamma_c}$$

4.6.4.1 Failure limit states are defined in Sec 6, where each limit state is defined by an equation and γ_c is to be determined such that it satisfies the equation.

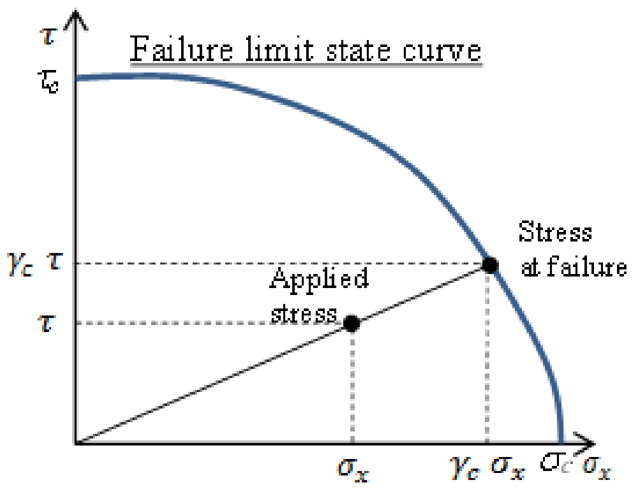


Fig.4.6.4.1 : Example of failure limit state curve and stress multiplication factor at failure

σ_x, τ : Applied stress combination for buckling given in 4.6.4.2

σ_c, τ_c : Critical buckling stresses to be obtained according to Sec 6 for stress combination for buckling σ_x and τ.

4.6.4.2 Stress combination for buckling assessment

4.6.4.2.1 Two stress combination as given in Table 4.6.4.2.1 are to be considered for each of the load cases "hogging" and "sagging". The stresses are to derived at the load calculation points

Table : 4.6.4.2.1				
		σ_x	σ_y	τ
Longitudinal stiffening	Stress combination 1	σ_{HG}	0	$0.7\tau_{HG}$
	Stress combination 2	$0.7\sigma_{HG}$	0	τ_{HG}
Transverse stiffening	Stress combination 1	0	σ_{HG}	$0.7\tau_{HG}$
	Stress combination 2	0	$0.7\sigma_{HG}$	τ_{HG}

4.6.4.3 Load calculation points

4.6.4.3.1 The hull girder stresses for elementary plate panels (EPP) are to be calculated at the load calculation points defined in Table 4.6.4.3.1

4.6.4.3.2 The hull girder stresses for longitudinal stiffeners are to be calculated at the following load calculation point:

- at the mid length of the considered stiffener
- at the intersection point between the stiffener and its attached plate.

Table 4.6.4.3.1 : Load calculation points (LCP) coordinates for plate buckling assessment

LCP coordinates	Hull girder bending stress		Hull girder shear stress
	Non horizontal plating	Horizontal plating	
X coordinate	Mid-length of the EPP		
Y coordinate	Both upper and lower ends of the EPP (points A1 and A2 in Fig.4.6.4.3.1)	Out board and inboard ends of the EPP (points A1 and A2 in Fig.4.6.4.3.1)	Mid-point of EPP (point B in Fig.4.6.4.3.1)
Z coordinate	Corresponding to x and y values		

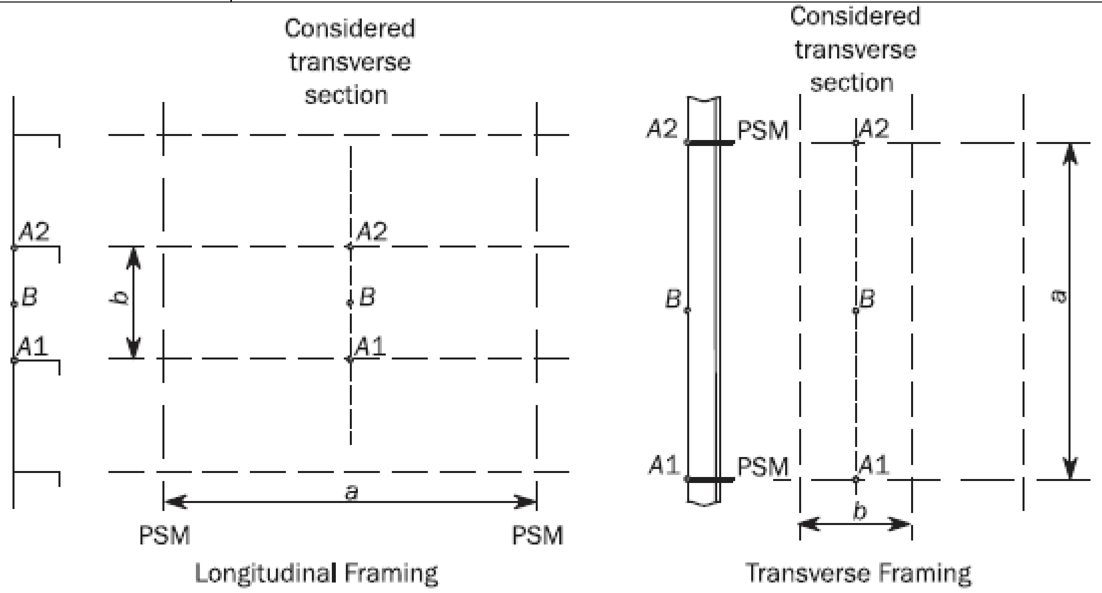


Fig.4.6.4.3.1 : LCP for plate buckling - assessment, PSM stands for primary supporting members

4.7 Hull girder ultimate strength

4.7.1 The hull girder ultimate strength is to be assessed for ships with length L equal or greater than 150 [m]. The method for calculation is given in detail in Sec 7.

4.7.2 Acceptance criteria given in 4.7.7 are applicable to intact ship structures.

4.7.3 Hull girder ultimate bending capacity is to be checked for the load cases "hogging" and "sagging".

4.7.4 The vertical hull girder bending moment, M in hogging and sagging conditions, to be considered in the ultimate strength check is to be taken as:

$$M = \gamma_s M_s + \gamma_w M_w$$

Where,

M_s = permissible still water bending moment [kNm]

M_w = Vertical wave bending moment [kNm]

γ_S=Partial safety factor for the still water bending moment, to be taken as 1

γ_w= Partial safety factor for the vertical wave bending moment, to be taken as 1.2

4.7.5 The Hull girder ultimate bending moment capacity, M_u is defined as the maximum bending moment capacity of the hull girder beyond which the hull structure collapses. The ultimate bending moment capacities of a hull girder transverse section, in hogging and sagging conditions, are defined as the maximum values of the curves of bending moment *M* versus the curvature *X* of the transverse section considered (M_{UH} for hogging condition and M_{US} for sagging condition). The curvature *X* is positive for hogging condition and negative for sagging condition.

4.7.6 The hull girder ultimate bending moment capacity M_U is to be calculated using the incremental-iterative method as given in Sec 7.2 or using an alternative method as indicated in Sec 7.3.

4.7.7 The hull girder ultimate bending capacity at any hull transverse section is to satisfy the following criteria:

$$M \leq \frac{M_U}{\gamma_M \gamma_{DB}}$$

M_U = Hull girder ultimate bending moment capacity [kNm] to be obtained as specified in 4.7.5 and 4.7.6.

γ_M=Partial safety factor for the hull girder ultimate bending capacity, covering material geometric and strength prediction uncertainties, to be taken as 1.05

γ_{DB}=Partial safety factor for the hull girder ultimate bending moment capacity, covering the effect of double bottom bending, to be taken as:

- For hogging condition

$$\gamma_{DB} = 1.15$$

- For sagging condition

$$\gamma_{DB} = 1$$

4.7.8 For cross sections where the double bottom breadth of the inner bottom is less than that at amidships or where the double bottom structure differs from that at amidships (e.g. engine room sections), the factor γ_{DB} for hogging condition may be reduced based upon agreement with IRS.

4.8 Requirements for large container ships

4.8.1 Application

4.8.1.1 For container ships with a breadth B greater than 32.26 [m], following requirements are applicable in addition to the requirements of 4.2 to 4.7.

4.8.2 Yield and buckling assessment

4.8.2.1 Yield and buckling assessment is to be specially considered, taking into consideration additional hull girder loads:

- Wave torsion
- Wave horizontal bending
- Static cargo torque
- Local loads

4.8.2.2 All in plane stress components (i.e. bi-axial and shear stress) induced by hull girder loads and local loads are to be considered during assessment.

4.8.3 Whipping

4.8.3.1 Hull girder strength assessment is to take into consideration the whipping contribution to the vertical bending moment.

4.9 Direct calculation of Shear Flow

4.9.1 General

4.9.1.1 This sub-section describes the procedures of direct calculation of shear flow around a ship's cross section due to hull girder vertical shear force. The shear flow q_v at each location in the cross section, is calculated by considering the cross section is subjected to a unit vertical shear force of 1 [N].

The unit shear flow per mm, q_v, [N/mm], is to be taken as:

$$q_v = q_D + q_I$$

where:

q_D : Determinate shear flow, as defined in 4.9.2.

q_I : Indeterminate shear flow which circulates around the closed cells, as defined in 4.9.3.

In the calculation of the unit shear flow, q_v, the longitudinal stiffeners are to be taken into account.

4.9.2 Determinate Shear Flow

4.9.2.1 The determinate shear flow, q_D [N/mm] at each location in the cross section is to be obtained from the following line integration:

$$q_D(s) = -\frac{1}{10^6 I_{y-net}} \int_0^s (z - z_n) t_{net} d_s$$

where:

s : Coordinate value of running coordinate along the cross section [m].

I_{y-net} : Net moment of inertia of the cross section [m^4].

t_{net} : Net thickness of plating [mm].

z_n : Z coordinate of horizontal neutral axis from baseline [m].

4.9.2.2 It is assumed that the cross section is composed of line segments as shown in Fig.4.9.2.1: where each line segment has a constant plate net thickness. The determinate shear flow is obtained by the following equation.

$$q_{Dk} = -\frac{t_{net}\ell}{2 \cdot 10^6 I_{Y-net}} (z_k + z_i - 2z_n) + q_{Di}$$

where:

q_{Dk}, q_{Di} : Determinate shear flow at node k and node i respectively [N/mm].

ℓ : Length of line segments [m].

y_k, y_i : Y coordinate of the end points k and i of line segment [m], as defined in Fig.4.9.2.1.

z_k, z_i : Z coordinate of the end points k and i of line segment [m], as defined in Fig.4.9.2.1 .

4.9.2.3 Where the cross section includes closed cells, the closed cells are to be cut with virtual slits, as shown in Fig.4.9.2.2: in order to obtain the determinate shear flow. These virtual slits must not be located in walls which form part of another closed cell.

4.9.2.4 Determinate shear flow at bifurcation points is to be calculated by water flow calculations, or similar, as shown in Fig.4.9.2.2.

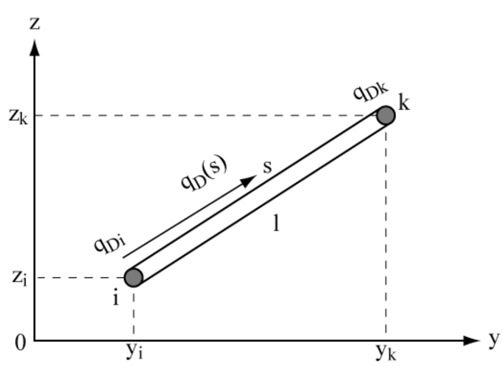


Fig.4.9.2.1 : Definition of line segment

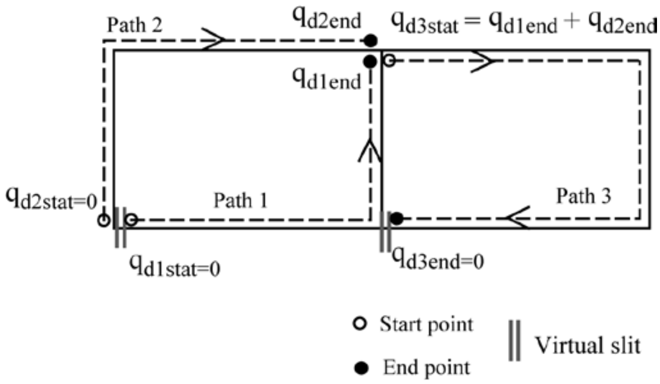


Fig.4.9.2.2 : Placement of virtual slits and calculation of determinate shear flow at bifurcation points

4.9.3 Indeterminate Shear Flow

4.9.3.1 The indeterminate shear flow around closed cells of a cross section is considered as a constant value within the same closed cell. The following system of equation for determination of indeterminate shear flows can be developed. In the equations, contour integrations of several parameters around all closed cells are performed.

$$q_{Ic} \oint_C \frac{1}{t_{net}} ds - \sum_{m=1}^{N_w} \left(q_{\mathrm{Im}} \oint_{c\&m} \frac{1}{t_{net}} ds \right) = -\oint_c \frac{q_D}{t_{net}} ds$$

where:

N_w : Number of common walls shared by cell c and all other cells.

c&m : Common wall shared by cells *c* and *m*

q_{Ic}, q_{Im} : Indeterminate shear flow around the closed cell *c* and *m* respectively [N/mm].

4.9.3.2 Under the assumption of the assembly of line segments shown in Fig.4.9.2.1 and constant plate thickness of each line segment, the above equation can be expressed as follows:

$$q_{Ic} \sum_{j=1}^{N_c} \left(\frac{l}{t_{net}} \right)_j - \sum_{m=1}^{N_w} \left\{ q_{Im} \left[\sum_{j=1}^{N_m} \left(\frac{l}{t_{net}} \right)_j \right]_m \right\} = - \sum_{j=1}^{N_c} \emptyset_j$$

$$\emptyset_j = \left[- \frac{l^2}{6 \times 10^3 I_{Y-net}} (z_k + 2z_i - 3z_n) + \frac{l}{t_{net}} q_{Di} \right]_j$$

where:

N_c : Number of line segments in cell *c*.

N_m : Number of line segments on the common wall shared by cells *c* and *m*.

q_{Di} : Determinate shear flow [N/mm], calculated according to 4.9.2.

4.9.3.3 The difference in the directions of running coordinates specified in 4.9.2 and in this section has to be considered.

4.9.4 Computation of sectional properties

4.9.4.1 Properties of the cross section are to be obtained by the following formulae where the cross section is assumed as the assembly of line segments:

$$\ell = \sqrt{(y_k - y_i)^2 + (z_k - z_i)^2}$$

$$a_{net} = 10^{-3} \ell t_{net}$$

$$A_{net} = \sum a_{net}$$

$$s_{y-net} = \frac{a_{net}}{2}(z_k + z_i)$$

$$S_{y-net} = \sum s_{y-net}$$

$$i_{y0-net} = \frac{a_{net}}{3}(z_k^2 + z_k z_i + z_i^2)$$

$$I_{y0-net} = \sum i_{y0-net}$$

where:

a_{net}, A_{net}: Area of the line segment and the cross section respectively [m^2].

s_{y-net}, S_{y-net}: First moment of the line segment and the cross section about the baseline [m^3].

i_{y0-net}, I_{y0-net}: Moment of inertia of the line segment and the cross section about the baseline [m^4].

4.9.4.2 The height of horizontal neutral axis, z_n, in [m], is to be obtained as follows:

$$z_n = \frac{S_{y-net}}{A_{net}}$$

4.9.4.3 Inertia moment about the horizontal neutral axis [m^4], is to be obtained as follows:

$$I_{y-net} = I_{y0-net} - z_n^2 A_{net}$$

Section 5

Local Structure

5.1 Bottom structure

5.1.1 The bottom structure is to be as per Pt.3, Ch.7, except that the increase of 2 [mm] on the inner bottom plating under cargo hatchways, or the alternative of fitting a ceiling, may be dispensed with if the holds are used exclusively for the carriage of containers.

5.1.2 Plate floors are to be fitted under bulkheads, midhold supports and quarter length supports and the maximum spacing is not to exceed 3.6 [m].

5.1.3 Local stiffening is to be provided under container corner seatings.

5.1.4 Thickness of floors is not to be less than

t = 6.0 + 0.03L [mm]

5.1.5 Where mid-hold support or quarter length supports are arranged for the double bottom, these are to take the form of an efficiently stiffened transverse box or open structure.

5.2 Side structure

5.2.1 Thickness of the strake immediately below the sheer strake is generally not to be less than 80 percent of the sheer strake thickness.

5.2.2 Side shell plating at positions of high local loads and also at the termination of double skin structure, may require local increase in thickness.

5.2.3 Side shell primary supporting structure is to be effectively supported at deck level. Scantlings of primary structure may require verification by direct calculations.

5.2.4 Transverses supporting side longitudinals are to be arranged in line with the plate floors in the double bottoms to ensure continuity of transverse strength.

5.2.5 Transverses and horizontal perforated flats inside double skin construction are to have a thickness not less than

t = 7.5 + 0.015L [mm] or

= 10 [mm] whichever is lower.

The flats and transverses are to be efficiently stiffened, and the thickness increased locally where necessary, to account for high shear stress.

5.3 Deck structure

5.3.1 The midship scantlings are generally to extend over the region of the container holds.

5.3.2 Decks are to be efficiently scarphed into the machinery space, and the fore end and aft end structure.

5.3.3 The scantlings of lower deck plating and stiffeners are to comply with the requirements of Pt.3, Ch.9; but the thickness may be required to be increased when the deck acts as a primary support for the side shell stiffening.

5.3.4 The scantlings of cross deck strips forming top of the bulkheads are to be specially considered in accordance with Pt.3, Ch.9, Sec.2.

The cross deck strips are in general to be transversely framed and the plating thickness is to satisfy the buckling criteria given in Pt.3, Ch.3.

5.3.5 Inserts are required at the intersection of the longitudinal underdeck girders and the cross deck strip. The inserts are to have a thickness not less than that of the girder top and bottom plates, as appropriate.

5.3.6 Longitudinal underdeck girders are, in general, to be fitted at deck level to support the hatch coamings. In case of ships with twin hatch openings abreast, the arrangement at deck centre may consist of one girder on the centreline, or one girder each on port and starboard in the breadth of the hatchway. The girders may take the form of open sections or closed box sections. Special consideration will be given to ships where the girders are omitted. The top and bottom flanges of these girders are to have a minimum width suitable to accommodate the hatch coamings and the hatch cover securing arrangements, and the scantlings will be specially considered. They are, in general, to be continuous throughout the container hold area, including the engine room where this is situated between container holds. Special attention is to be given to the integration of these girders into the fore end structure, machinery spaces where situated aft, and the intersection of the girders and the transverse box girders.

5.3.7 Coamings are, in general, to have a thickness, t, not less than the greater of the following:

a) $t = 8\, h_{HC} \sqrt{k}$ [mm]

where h_{HC} is the height of coaming [m]

b) t = 11 [mm] where length $L \geq 60$ [m], and not less than 9 [mm] where length $L \leq 30$ [m]. Intermediate values are to be obtained by interpolation.

The coamings are to be efficiently stiffened and stayed, see also Pt.3, Ch.11, Sec.5. Continuous coamings are to be effectively scarphed into the deckhouse structure or gradually tapered at ends, as applicable.

5.3.8 The corners of main hatchway openings are generally be rounded with radii not less than:

i) 350 + 0.525L [mm] outboard radius

ii) 200+0.3L [mm] inboard radius (min.250[mm]).

The radius of the hatch corners of the main hatchway openings adjacent to the engine room is to be made as large as practicable, approximately 40B [mm]. Parabolic or elliptic corners will be given special consideration.

5.3.9 Attention is to be paid to structural continuity, and abrupt change of shape, section and plate thicknesses are to be avoided. Arrangements in way of corners and openings are to be such as to minimize stress concentration.

In general, small openings should not be arranged in the strength deck outside line of main hatchways in the region of container holds with wide hatches.

5.4 Bulkheads

5.4.1 Where fitted, inner skin longitudinal bulkheads may be transversely or longitudinally framed. The continuity of the longitudinal material must be maintained in way of the container holds and also the machinery space where it is situated between container holds.

5.4.2 Where the inner skin bulkheads are stepped to accommodate the container stowage arrangement, the scantlings and stiffening arrangement will be required to be specially considered. The scarphing arrangements in way of the steps are to be sufficient to ensure an efficient overlap of the inner skin bulkheads.

5.4.3 For inner skin bulkheads, in general, the thickness of the strake below the top strake is to be not less than 80 per cent of the top strake thickness.

5.4.4 At transverse watertight bulkheads, in general, a transverse box structure is to be arranged at tank top and deck level, and a system of vertical webs and/or horizontal stringers arranged to support the secondary stiffeners. The webs are to be fitted in line with the longitudinal underdeck girders and the corresponding double bottom side girders. Where the depth to breadth ratio of the bulkhead is large, the scantlings of the primary supporting members are to be determined by direct calculation.

5.4.5 Where non-watertight bulkheads are arranged in conjunction with the double bottom mid-hold support, a transverse box is to be arranged at deck level.

Section 6

Buckling Capacity

The buckling assessment required by 4.6.4 for plates and stiffeners are to be determined using the methods detailed in this section.

6.1 Elementary Plate Panel

6.1.1 General

6.1.1.1 Definitions

6.1.1.1 An Elementary Plate Panel (EPP) is the unstiffened part of the plating between stiffeners and/or primary supporting members.

6.1.1.2 All the edges of the elementary plate panel are forced to remain straight (but free to move in the in-plane directions) due to the surrounding structure/neighbouring plates (usually longitudinal stiffened panels in deck, bottom and inner-bottom plating, shell and longitudinal bulkheads).

6.1.2 Symbols

6.1.2.1 Refer to table 6.1.2, for description of symbols used in this section.

6.1.3 EPP with different thicknesses

6.1.3.1 Longitudinally stiffened EPP with different thicknesses

6.1.3.1.1 In longitudinal stiffening arrangement, when the plate thickness varies over the width, *b* [mm], of a plate panel, the buckling capacity is calculated on an equivalent plate panel width, having a thickness equal to the smaller plate thickness, t_1. The width of this equivalent plate panel, b_{eq} [mm], is defined by the following formula:

$$b_{eq} = \ell_1 + \ell_2 \left(\frac{t_1}{t_2}\right)^{1.5}$$

where:

ℓ_1 : Width of the part of the plate panel with the smaller plate thickness, t_1 [mm], as defined in Fig.6.1.3.1.1.

ℓ_2 : Width of the part of the plate panel with the greater plate thickness, t_2 [mm], as defined in Fig.6.1.3.1.1.

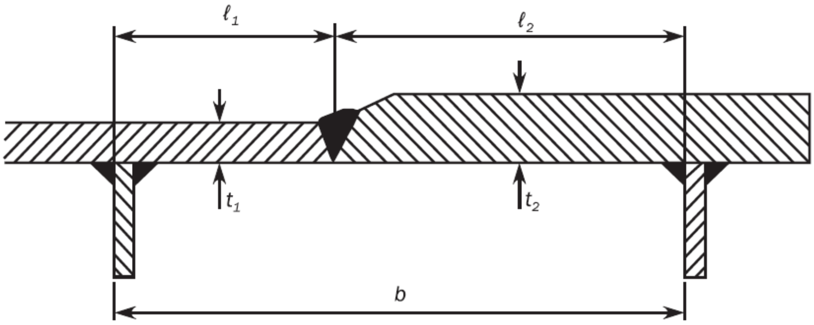


Fig.6.1.3.1.1 : Plate thickness change over the width

Table 6.1.2 : Symbols

x axis	: Local axis of a rectangular buckling panel parallel to its long edge.
y axis	: Local axis of a rectangular buckling panel perpendicular to its long edge.
σ_x	: Membrane stress applied in *x* direction [N/mm^2]
σ_y	: Membrane stress applied in *y* direction [N/mm^2]
τ	: Membrane shear stress applied in *xy* plane [N/mm^2]
σ_a	: Axial stress in the stiffener [N/mm²]
σ_b	: Bending stress in the stiffener [N/mm²]
σ_w	: Warping stress in the stiffener [N/mm²]
$\sigma_{cx}, \sigma_{cy}, \tau_c$	: Critical stress [N/mm^2], defined in 6.2.1.1 for plates.
R_{eH_S}	: Specified minimum yield stress of the stiffener [N/mm²]
R_{eH_P}	: Specified minimum yield stress of the plate [N/mm²]
a	: Length of the longer side of the plate panel as shown in Table 6.2.1.2.1 [mm].
b	: Length of the shorter side of the plate panel as shown in Table6.2.1.2.1 [mm].
d	: Length of the side parallel to the axis of the cylinder corresponding to the curved plate panel as shown in Table 6.2.1.2.2 [mm].
σ_E	: Elastic buckling reference stress [N/mm^2] to be taken as: • For the application of plate limit state according to 6.2.1.2: $\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_p}{b}\right)^2$ • For the application of curved plate panels according to 6.2.2: $\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_p}{d}\right)^2$
v	: Poisson's ratio to be taken equal to 0.3
t_p	: Net thickness of plate panel [mm]
t_w	: Net stiffener web thickness [mm]
t_f	: Net flange thickness [mm]
b_f	: Breadth of the stiffener flange [mm]
h_w	: Stiffener web height [mm]
e_f	: Distance from attached plating to centre of flange [mm], to be taken as: $e_f = h_w$ for flat bar profile. $e_f = h_w - 0.5\ t_f$ for bulb profile. $e_f = h_w + 0.5\ t_f$ for angle and Tee profiles.
α	: Aspect ratio of the plate panel, to be taken as $\alpha = \frac{a}{b}$
β	: Coefficient taken as $\beta = \frac{1-\psi}{\alpha}$
ψ	: Edge stress ratio to be taken as $\psi = \frac{\sigma_2}{\sigma_1}$
σ_1	: Maximum stress [N/mm²]
σ_2	: Minimum stress [N/mm²]
R	: Radius of curved plate panel [mm]
ℓ	: Span, in mm, of stiffener equal to the spacing between primary supporting members
s	: Spacing of stiffener [mm], to be taken as the mean spacing between the stiffeners of the considered stiffened panel.

6.1.3.2 Transversally stiffened EPP with different thicknesses

6.1.3.2.1 In transverse stiffening arrangement, when an EPP is made of different thicknesses, the buckling check of the plate and stiffeners is to be made for each thickness considered constant on the EPP.

6.2 Buckling capacity of plates

6.2.1 Plate panel

6.2.1.1 Plate limit state

6.2.1.1.1.The plate limit state is based on the following interaction formulae:

a) Longitudinal stiffening arrangement:

$$\left(\frac{\gamma_C \sigma_x}{\sigma_{cx}}\right)^{2/\beta_p^{0.25}} + \left(\frac{\gamma_C |\tau|}{\tau_c}\right)^{2/\beta_p^{0.25}} = 1$$

b) Transverse stiffening arrangement:

$$\left(\frac{\gamma_C \sigma_y}{\sigma_{cy}}\right)^{2/\beta_p^{0.25}} + \left(\frac{\gamma_C |\tau|}{\tau_c}\right)^{2/\beta_p^{0.25}} = 1$$

where:

σ_x, σ_y : Applied normal stress to the plate panel [N/mm²], as defined in *Sec 4.6.3.2*, at load calculation points of the considered elementary plate panel.

τ : Applied shear stress to the plate panel [N/mm²], as defined in *Sec 4.6.3.2*, at load calculation points of the considered elementary plate panel.

σ_{cx} : Ultimate buckling stress [N/mm²] in direction parallel to the longer edge of the buckling panel as defined in 6.2.1.3

σ_{cy} : Ultimate buckling stress [N/mm²] in direction parallel to the shorter edge of the buckling panel as defined in 6.2.1.3

τ_c :Ultimate buckling shear stress [N/mm²] as defined in 6.2.1.3

β_p : Plate slenderness parameter taken as:

$$\beta_p = \frac{b}{t_p}\sqrt{\frac{R_{eH\_P}}{E}}$$

R_{eH_P} : Specified minimum yield stress of the stiffener [N/mm^2]

t_p : Net thickness of plate panel [mm]

6.2.1.2 Reference degree of slenderness

6.2.1.2.1 The reference degree of slenderness is to be taken as:

$$\lambda = \sqrt{\frac{R_{eH\_P}}{K\sigma_E}}$$

where:

K : Buckling factor, as defined in Table 6.2.1.2.1 and Table 6.2.1.2.2.

σ_E : Elastic buckling reference stress [N/mm^2]

$$\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_p}{b}\right)^2$$

6.2.1.3 Ultimate buckling stresses

6.2.1.3.1 The ultimate buckling stress of plate panels [N/mm²], is to be taken as:

$$\sigma_{cx} = C_x R_{eH\_P}$$

$$\sigma_{cy} = C_y R_{eH\_P}$$

6.2.1.3.2 The ultimate buckling stress of plate panels subject to shear [N/mm²], is to be taken as:

$$\tau_c = C_\tau \frac{R_{eH\_P}}{\sqrt{3}}$$

where:

C_x, C_y, C_τ : Reduction factors, as defined in Table 6.2.1.2.1

6.2.1.3.3 The boundary conditions for plates are to be considered as simply supported (see cases 1, 2 and 15 of Table 6.2.1.2.1. If the boundary conditions differ significantly from simple support, a more appropriate boundary condition can be applied according to the different cases of Table 6.2.1.2.2 subject to the agreement of IRS.

6.2.1.4 Correction Factor F_{long}

6.2.1.4.1 The correction factor F_{long} depending on the edge stiffener types on the longer side of the buckling panel is defined in Table 6.2.1.4. An average value of F_{long} is to be used for plate panels having different edge stiffeners. For stiffener types other than those mentioned in Table 6.2.1.4, the value of *c* is to be agreed by IRS. In such a case, value of *c* higher than those mentioned in Table 6.2.1.4 can be used, provided it is verified by buckling strength check of panel using non-linear FE analysis and deemed appropriate by IRS.

<table>
<tr><th colspan="5">Table 6.2.1.4 : Correction Factor F_{long}</th></tr>
<tr><th colspan="3">Structural element types</th><th>F_{long}</th><th>c</th></tr>
<tr><td colspan="3">Unstiffened Panel</td><td>1.0</td><td>N/A</td></tr>
<tr><td rowspan="6">Stiffened Panel</td><td colspan="2">Stiffener not fixed at both ends</td><td>1.0</td><td>N/A</td></tr>
<tr><td rowspan="5">Stiffener fixed at both ends</td><td>Flat bar [1]</td><td rowspan="4">$F_{long} = c + 1 \quad for \quad \frac{t_w}{t_p} > 1$
$F_{long} = c\left(\frac{t_w}{t_p}\right)^3 + 1 \quad for \quad \frac{t_w}{t_p} \le 1$</td><td>0.10</td></tr>
<tr><td>Bulb profile</td><td>0.30</td></tr>
<tr><td>Angle profile</td><td>0.40</td></tr>
<tr><td>T profile</td><td>0.30</td></tr>
<tr><td>Girder of high rigidity (e.g. bottom transverse)</td><td>1.4</td><td>N/A</td></tr>
<tr><td colspan="5">[1] t_w is the net web thickness, in [mm], without the correction defined in 6.4.3.5</td></tr>
</table>

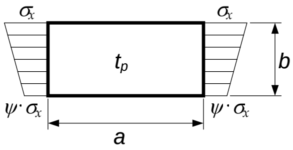
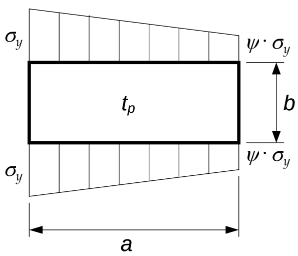
<table>
<tr><th colspan="5">Table 6.2.1.2.1: Buckling Factor and reduction factor for plane plate panels</th></tr>
<tr><th>Case</th><th>Stress ratio ψ</th><th>Aspect ratio α</th><th>Buckling factor K</th><th>Reduction factor C</th></tr>
<tr><td rowspan="3">1

</td><td>1 ≥ ψ ≥ 0</td><td colspan="2">$K_x = F_{long} \dfrac{8.4}{\psi + 1.1}$</td><td rowspan="3">$C_x = 1$ for $\lambda \le \lambda_c$
$C_x = c\left(\dfrac{1}{\lambda} - \dfrac{0.22}{\lambda^2}\right)$ for $\lambda > \lambda_c$
where:
$c = (1.25 - 0.12\psi) \le 1.25$
$\lambda_c = \dfrac{c}{2}\left(1 + \sqrt{1 - \dfrac{0.88}{c}}\right)$</td></tr>
<tr><td>0 > ψ > -1</td><td colspan="2">$K_x = F_{long}\left[7.63 - \psi(6.26 - 10\psi)\right]$</td></tr>
<tr><td>ψ ≤ -1</td><td colspan="2">$K_x = F_{long}\left[5.975(1-\psi)^2\right]$</td></tr>
<tr><td rowspan="7">2

</td><td rowspan="3">1 ≥ ψ ≥ 0</td><td colspan="2">$K_y = \dfrac{2\left(1 + \dfrac{1}{\alpha^2}\right)^2}{1 + \psi + \dfrac{(1-\psi)}{100}\left(\dfrac{2.4}{\alpha^2} + 6.9 f_1\right)}$</td><td rowspan="7">$C_y = c\left(\dfrac{1}{\lambda} - \dfrac{R + F^2(H-R)}{\lambda^2}\right)$
where:
$c = (1.25 - 0.12\psi) \le 1.25$
$R = \lambda(1 - \lambda / c)$ for $\lambda < \lambda_c$
$R = 0.22$ for $\lambda \ge \lambda_c$
$\lambda_c = 0.5\, c\left(1 + \sqrt{1 - 0.88 / c}\right)$
$F = \left(1 - \left(\dfrac{K}{0.91} - 1\right) / \lambda_p^2\right) c_1 \ge 0$
$\lambda_p^2 = \lambda^2 - 0.5$ for $1 \le \lambda_p^2 \le 3$
$c_1 = \left(1 - \dfrac{1}{\alpha}\right) \ge 0$
$H = \lambda - \dfrac{2\lambda}{c(T + \sqrt{T^2 - 4})} \ge R$
$T = \lambda + \dfrac{14}{15\lambda} + \dfrac{1}{3}$</td></tr>
<tr><td>α ≤ 6</td><td>$f_1 = (1-\psi)(\alpha - 1)$</td></tr>
<tr><td>α > 6</td><td>$f_1 = 0.6\left(1 - \dfrac{6\psi}{\alpha}\right)\left(\alpha + \dfrac{14}{\alpha}\right)$
But not greater than
$14.5 - \dfrac{0.35}{\alpha^2}$</td></tr>
<tr><td rowspan="4">0 > ψ ≥ 1-4α/3</td><td colspan="2">$K_y = \dfrac{200(1+\beta^2)^2}{(1 - f_3)(100 + 2.4\beta^2 + 6.9 f_1 + 23 f_2)}$</td></tr>
<tr><td>α > 6(1- ψ)</td><td>$f_1 = 0.6\left(\dfrac{1}{\beta} + 14\beta\right)$
but not greater than 14.5-0.35β²
$f_2 = f_3 = 0$</td></tr>
<tr><td>3(1- ψ)≤α ≤ 6(1- ψ)</td><td>$f_1 = \dfrac{1}{\beta} - 1$
$f_2 = f_3 = 0$</td></tr>
<tr><td>1.5(1- ψ)≤α < 3(1- ψ)</td><td>$f_1 = \dfrac{1}{\beta} - (2 - \omega\beta)^4 - 9(\omega\beta - 1)\left(\dfrac{2}{3} - \beta\right)$
$f_2 = f_3 = 0$</td></tr>
</table>

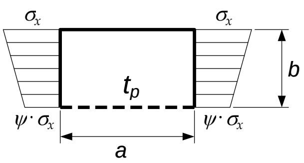
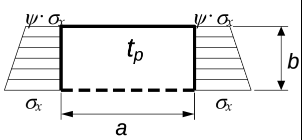
Table 6.2.1.2.1: Buckling Factor and reduction factor for plane plate panels				
Case	**Stress ratio** ***ψ***	**Aspect ratio** ***α***	**Buckling factor *K***	**Reduction factor *C***
		$1-\psi \le \alpha < 1.5(1-\psi)$	For α > 1.5: $f_1 = 2\left(\frac{1}{\beta} - 16\left(1-\frac{\omega}{3}\right)^4\right)\left(\frac{1}{\beta}-1\right)$ $f_2 = 3\beta - 2$ $f_3 = 0$ For α ≤ 1.5: $f_1 = 2\left(\frac{1.5}{1-\psi} - 1\right)\left(\frac{1}{\beta}-1\right)$ $f_2 = \frac{\psi\left(1-16 f_4^2\right)}{1-\alpha}$ $f_3 = 0$ $f_4 = (1.5 - Min(1.5;\alpha))^2$	
		$0.75(1-\psi) \le \alpha < 1-\psi$	$f_1 = 0$ $f_2 = 1 + 2.31(\beta - 1) - 48\left(\frac{4}{3} - \beta\right) f_4^2$ $f_3 = 3 f_4 (\beta - 1)\left(\frac{f_4}{1.81} - \frac{\alpha - 1}{1.31}\right)$ $f_4 = (1.5 - Min(1.5;\alpha))^2$	
	$\psi < 1 - 4\alpha/3$	$K_y = 5.972 \frac{\beta^2}{1 - f_3}$ where: $f_3 = f_5\left(\frac{f_5}{1.81} + \frac{1+3\psi}{5.24}\right)$ $f_5 = \frac{9}{16}\left(1 + Max(-1;\psi)\right)^2$		
3 	$1 \ge \psi \ge 0$	$K_x = \frac{4(0.425 + 1/\alpha^2)}{3\psi + 1}$		$C_x = 1$ for $\lambda \le 0.7$ $C_x = \frac{1}{\lambda^2 + 0.51}$ for $\lambda > 0.7$
	$0 > \psi \ge -1$	$K_x = 4(0.425 + 1/\alpha^2)(1+\psi) - 5\psi(1 - 3.42\psi)$		
4 	$1 \ge \psi \ge -1$	$K_x = \left(0.425 + \frac{1}{\alpha^2}\right)\frac{3-\psi}{2}$		

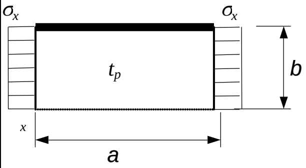
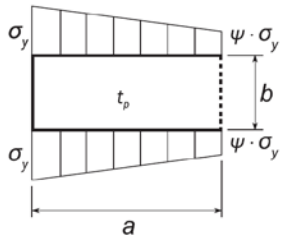
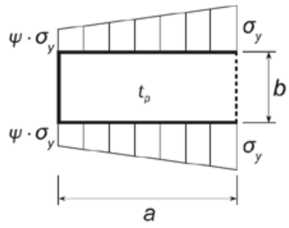
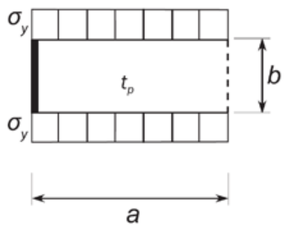
Table 6.2.1.2.1: Buckling Factor and reduction factor for plane plate panels				
Case	**Stress ratio ψ**	**Aspect ratio α**	**Buckling factor K**	**Reduction factor C**
5 	—	$\alpha \geqslant 1.64$	$K_x = 1.28$	
		$\alpha < 1.64$	$K_x = \frac{1}{\alpha^2} + 0.56 + 0.13\alpha^2$	
6 	$1 \geqslant \psi \geqslant 0$		$K_y = \frac{4(0.425 + \alpha^2)}{(3\psi + 1)\alpha^2}$	$C_y = 1$ for $\lambda \leq 0.7$ $C_y = \frac{1}{\lambda^2 + 0.51}$ for $\lambda > 0.7$
	$0 > \psi \geqslant -1$		$K_y = 4(0.425 + \alpha^2)(1 + \psi)\frac{1}{\alpha^2} - 5\psi(1 - 3.42\psi)\frac{1}{\alpha^2}$	
7 	$1 \geqslant \psi \geqslant -1$		$K_y = (0.425 + \alpha^2)\frac{(3 - \psi)}{2\alpha^2}$	
8 	-		$K_y = 1 + \frac{0.56}{\alpha^2} + \frac{0.13}{\alpha^4}$	

Table 6.2.1.2.1: Buckling Factor and reduction factor for plane plate panels

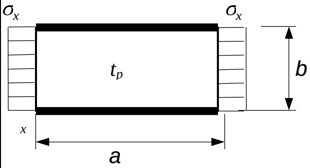
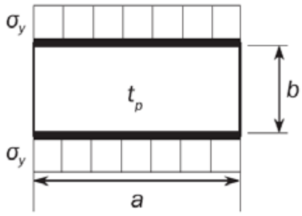
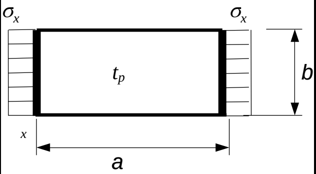
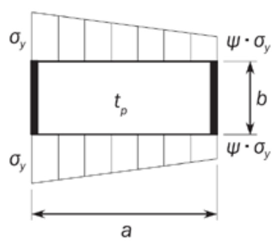
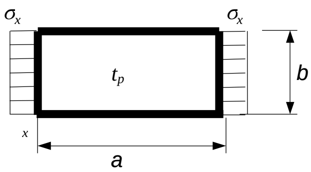
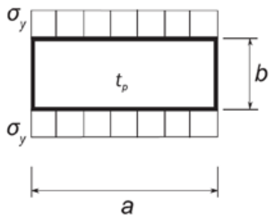
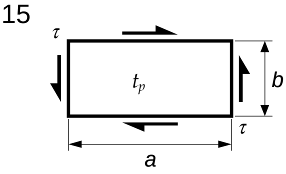
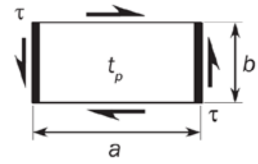
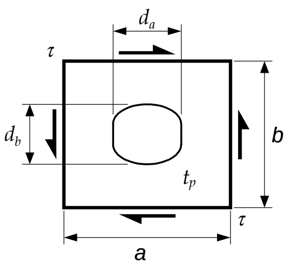
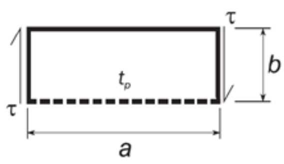
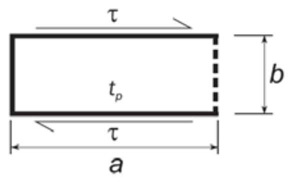
Case	Stress ratio ψ	Aspect ratio α	Buckling factor *K*	Reduction factor *C*
9 	-		$K_x = 6.97$	$C_x = 1$ for $\lambda \le 0.83$ $C_x = 1{,}13\left[\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right]$ for $\lambda > 0.83$
10 	-		$K_y = 4 + \frac{2.07}{\alpha^2} + \frac{0.67}{\alpha^4}$	
11 	-	$\alpha \ge 4$	$K_x = 4$	
		$\alpha < 4$	$K_x = 4 + 2.74\left(\frac{4-\alpha}{3}\right)^4$	
12 	-		K_y = K_y determined as per case 2	• For $\alpha < 2$: $C_y = C_{y2}$ • For $\alpha \geqslant 2$: $C_y = \left(1.06 + \frac{1}{10\alpha}\right) C_{y2}$ where: C_{y2}= C_y determined as per case 2
13 	-	$\alpha \ge 4$	$K_x = 6.97$	$C_x = 1$ for $\lambda \le 0.83$ $C_x = 1{,}13\left[\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right]$ for $\lambda > 0.83$
		$\alpha < 4$	$K_x = 6.97 + 3.1\left(\frac{4-\alpha}{3}\right)^4$	
14 	-		$K_y = \frac{6.97}{\alpha^2} + \frac{3.1}{\alpha^2}\left[\frac{4 - 1/\alpha}{3}\right]^4$	$C_y = 1$ for $\lambda \le 0.83$ $C_y = 1.13\left(\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right)$ for $\lambda > 0.83$

Table 6.2.1.2.1: Buckling Factor and reduction factor for plane plate panels				
Case	**Stress ratio** ψ	**Aspect ratio** α	**Buckling factor** ***K***	**Reduction factor** ***C***
15 	-		$K_\tau = \sqrt{3}\left[5.34 + \frac{4}{\alpha^2}\right]$	
16 	-		$K_\tau = \sqrt{3}\left\{5.34 + Max\left[\frac{4}{\alpha^2}; \frac{7.15}{\alpha^{2.5}}\right]\right\}$	$C_\tau = 1$ for $\lambda \le 0.84$ $C_\tau = \frac{0.84}{\lambda}$ for $\lambda > 0.84$
17 	-		*K* = *K*'*r* *K*' = *K* according to case 15. *r* = opening reduction factor taken as $r = \left(1 - \frac{d_a}{a}\right)\left(1 - \frac{d_b}{b}\right)$ with $\frac{d_a}{a} \le 0.7$ and $\frac{d_b}{b} \le 0.7$	
18 	-		$K_\tau = 3^{0.5}(0.6 + 4/\alpha^2)$	$C_\tau = 1$ for $\lambda \le 0.84$ $C_\tau = \frac{0.84}{\lambda}$ for $\lambda > 0.84$
19 	-		$K_\tau = 8$	

Edge boundary conditions:

- - - - - - - - - Plate edge free.

———— Plate edge simply supported.

▬▬▬▬ Plate edge clamped.

Notes:

1) Cases listed are general cases. Each stress component (σx, σy) is to be understood in local coordinates.

6.2.2 Curved plate panels

6.2.2.2.1 This requirement for curved plate limit state is applicable when $R/t_p \le 2500$. Otherwise, the requirement for plate limit state given in 6.2.1.1 is applicable.

Where,

R : Radius of curved plate panel, in [mm]

6.2.2.2.2The curved plate limit state is based on the following interaction formula:

$$\left(\frac{\gamma_c \sigma_{ax}}{C_{ax} R_{eH\_P}}\right)^{1.25} + \left(\frac{\gamma_c \tau \sqrt{3}}{C_\tau R_{eH\_P}}\right)^{2} = 1.0$$

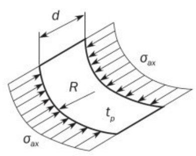
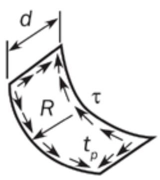
where:

σ_{ax} : Applied axial stress to the cylinder corresponding to the curved plate panel [N/mm²]. In case of tensile axial stresses, $\sigma_{ax}=0$.

C_{ax}, C_τ : Buckling reduction factor of the curved plate panel, as defined in Table 6.2.1.2.2.

6.2.2.2.3 The stress multiplier factor γ_c of the curved plate panel needs not be taken less than the stress multiplier factor γ_c for the expanded plane panel according to 6.2.1.1.

Table 6.2.1.2.2 : Buckling Factor and reduction factor for curved plate panel with $R/t_p \le 2500$

Case	Aspect ratio	Buckling factor K	Reduction factor C
1 	$\frac{d}{R} \le 0.5\sqrt{\frac{R}{t_p}}$	$K = 1 + \frac{2}{3}\frac{d^2}{Rt_p}$	For general application: $C_{ax} = 1$ for $\lambda \le 0.25$ $C_{ax} = 1.233-0.933\lambda$ for $0.25<\lambda\le 1$ $C_{ax} = 0.3/\lambda^3$ for $1<\lambda\le 1.5$ $C_{ax} = 0.2/\lambda^2$ for $\lambda>1.5$ For curved single fields, e.g. bilge strake, which are bounded by plane panels: $C_{ax} = 0.65/\lambda^2 \le 1.0$
	$\frac{d}{R} > 0.5\sqrt{\frac{R}{t_p}}$	$K = 0.267\frac{d^2}{Rt_p}\left[3 - \frac{d}{R}\sqrt{\frac{t_p}{R}}\right]$ $\ge 0.4\frac{d^2}{Rt_p}$	
2 	$\frac{d}{R} \le 8.7\sqrt{\frac{R}{t_p}}$	$K = \sqrt{3}\sqrt{28.3 + \frac{0.67d^3}{R^{1.5}t_p^{1.5}}}$	$C_\tau = 1$ for $\lambda \le 0.4$ $C_\tau = 1.274 - 0.686\lambda$ for $0.4 < \lambda \le 1.2$ $C_\tau = 0.65/\lambda^2$ for $\lambda > 1.2$
	$\frac{d}{R} > 8.7\sqrt{\frac{R}{t_p}}$	$K = \sqrt{3}\frac{0.28d^2}{R\sqrt{Rt_p}}$	
Explanations for boundary conditions: ———— Plate edge simply supported.			

6.3 Buckling Capacity of overall stiffened panel

6.3.1 The elastic stiffened panel limit state is based on the following interaction formula:

$$\frac{P_z}{c_f} = 1$$

where P_z and c_f are defined in 6.4.4.3.

6.4 Buckling capacity of longitudinal stiffeners

6.4.1 Stiffeners limit states

6.4.1.1 The buckling capacity of longitudinal stiffeners is to be checked for the following limit states:

- Stiffener induced failure (*SI*).

- Associated plate induced failure (*PI*).

6.4.2 Lateral pressure

6.4.2.1 The lateral pressure is to be considered as constant in the buckling strength assessment of longitudinal stiffeners.

6.4.3 Stiffener idealization

6.4.3.1 Effective length of the stiffener ℓ_{eff}

6.4.3.1.1 The effective length of the stiffener ℓ_{eff}, in mm, is to be taken equal to:

$\ell_{eff} = \frac{\ell}{\sqrt{3}}$ for stiffener fixed at both ends.

$\ell_{eff} = 0.75\ell$ for stiffener simply supported at one end and fixed at the other.

$\ell_{eff} = \ell$ for stiffener simply supported at both ends.

6.4.3.2 Effective width of the attached plating b_{eff1}

6.4.3.2.1 The effective width of the attached plating of a stiffener b_{eff1} [mm], without the shear lag effect is to be taken equal to:

$$b_{eff1} = \frac{C_{x1}b_1 + C_{x2}b_2}{2}$$

where:

C_{x1}, C_{x2} : Reduction factor defined in Table 6.2.1.2.1 calculated for the EPP1 and EPP2 on each side of the considered stiffener according to case 1.

b_1, b_2 : Width of plate panel on each side of the considered stiffener [mm].

6.4.3.3 Effective width of attached plating b_{eff}

6.4.3.3.1 The effective width of attached plating of stiffeners, b_{eff} [mm], is to be taken as:

$$b_{eff} = min(b_{eff1}, \chi_s s)$$

where:

χ_s : Effective width coefficient to be taken as:

- $\chi_s = min\left[\frac{1.12}{1+\frac{1.75}{\left(\frac{\ell_{eff}}{s}\right)^{1.6}}};1\right]$ for $\frac{\ell_{eff}}{s} \geq 1$

- $\chi_s = 0.407\frac{\ell_{eff}}{s}$ for $\frac{\ell_{eff}}{s} < 1$

6.4.3.4 Net thickness of attached plating t_p

6.4.3.4.1 The net thickness of plate t_p [mm], is to be taken as the mean thickness of the two attached plating panels

6.4.3.5 Effective web thickness of flat bar

6.4.3.5.1 For accounting the decrease of stiffness due to local lateral deformation, the effective web thickness of flat bar stiffener, in mm, is to be used for the calculation of the net sectional area, A_s, the net section modulus, Z, and the moment of inertia, I, of the stiffener and is taken as:

$$t_{w\_red} = t_w\left(1-\frac{2\pi^2}{3}\left(\frac{h_w}{s}\right)^2\left(1-\frac{b_{eff1}}{s}\right)\right)$$

6.4.3.6 Net section modulus Z of a stiffener

6.4.3.6.1 The net section modulus Z of a stiffener [cm^3], including effective width of plating b_{eff} is to be taken equal to:

- the section modulus calculated at the top of stiffener flange for stiffener induced failure (*SI*).
- the section modulus calculated at the attached plating for plate induced failure (*PI*).

6.4.3.7 Net moment of inertia I of a stiffener

6.4.3.7.1 The net moment of inertia I [cm^4], of a stiffener including effective width of attached plating b_{eff} is to comply with the following requirement:

$$\boldsymbol{I} \geq \frac{\boldsymbol{s\, t_p^3}}{\boldsymbol{12 \cdot 10^4}}$$

6.4.3.8 Idealisation of bulb profile

6.4.3.8.1 Bulb profiles may be considered as equivalent angle profiles. The net dimensions of the equivalent built-up section are to be obtained [mm], from the following formulae.

$$h_w = h_w' - \frac{h_w'}{9.2} + 2$$

$$b_f = \alpha\left(t_w' + \frac{h_w'}{6.7} - 2\right)$$

$$t_f = \frac{h_w'}{9.2} - 2$$

$$t_w = t_w'$$

where:

h'_w, t'_w : Net height and thickness of a bulb section [mm], as shown in Fig.6.4.3.8.

α : Coefficient equal to:

$\alpha = 1.1 + \frac{(120-h_w')^2}{3000}$ for $h'_w \le 120$

$\alpha = 1.0$ for $h'_w > 120$

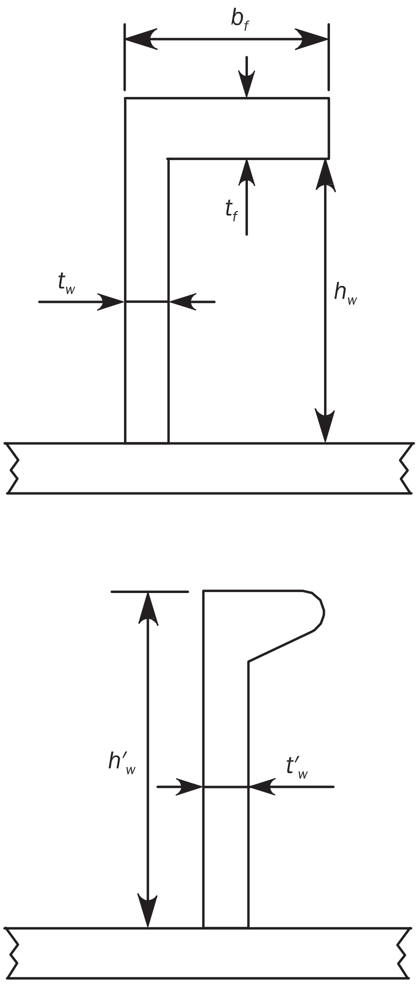


Fig.6.4.3.8 : Idealisation of bulb stiffener

6.4.4 Ultimate buckling capacity

6.4.4.1 Longitudinal stiffener limit state

6.4.4.1.1 When $\sigma_a + \sigma_b + \sigma_w > 0$, the ultimate buckling capacity for stiffeners is to be checked according to the following interaction formula:

$$\frac{\gamma_c \sigma_a + \sigma_b + \sigma_w}{R_{eH}} = 1$$

where:

σ_a : Effective axial stress [N/mm²], at mid-span of the stiffener, defined in 6.4.4.2.

σ_b : Bending stress in the stiffener [N/mm²], defined in 6.4.4.3.

σ_w : Stress due to torsional deformation [N/mm²], defined in 6.4.4.4.

R_{eH} : Specified minimum yield stress of the material [N/mm²]:

$R_{eH} = R_{eH-S}$ for stiffener induced failure (*SI*).

$R_{eH} = R_{eH-P}$ for plate induced failure (*PI*).

6.4.4.2 Effective axial stress σ_a

6.4.4.2.1 The effective axial stress σ_a [N/mm²], at mid-span of the stiffener, acting on the stiffener with its attached plating is to be taken equal to:

$$\sigma_a = \sigma_x \frac{s t_p + A_s}{b_{eff1} t_p + A_s}$$

where:

σ_x : Nominal axial stress [N/mm^2], acting on the stiffener with its attached plating, calculated according to Row 1 of Table 4.6.3.2.1 at load calculation point of the stiffener.

A_s : Net sectional area [mm^2], of the considered stiffener.

6.4.4.3 Bending stress σ_b

6.4.4.3.1 The bending stress in the stiffener σ_b [N/mm²], is to be taken equal to:

$$\sigma_b = \frac{M_0 + M_1}{Z} 10^{-3}$$

where:

M_1 : Bending moment [Nmm], due to the lateral load P:

$$M_1 = C_i \frac{|P| s \ell^2}{24} 10^{-3} \quad \text{for continuous stiffener}$$

$$M_1 = C_i \frac{|P| s \ell^2}{8} 10^{-3} \quad \text{for sniped stiffener}$$

P : Lateral load [kN/m^2], to be taken equal to the static pressure at the load calculation point of the stiffener.

C_i : Pressure coefficient:

$C_i = C_{SI}$ for stiffener induced failure (*SI*).

$C_i = C_{PI}$ for plate induced failure (*PI*).

C_{PI} : Plate induced failure pressure coefficient:

C_{PI} = 1 if the lateral pressure is applied on the side opposite to the stiffener.

C_{PI} = -1 if the lateral pressure is applied on the same side as the stiffener.

C_{SI} : Stiffener induced failure pressure coefficient:

C_{SI} = -1 if the lateral pressure is applied on the side opposite to the stiffener.

C_{SI} = 1 if the lateral pressure is applied on the same side as the stiffener.

M_0 : Bending moment [Nm], due to the lateral deformation w of stiffener:

$$M_0 = F_E \left(\frac{P_z w}{c_f - P_z} \right) \quad \text{with} \quad c_f - P_z > 0.$$

F_E : Ideal elastic buckling force of the stiffener [N].

$$F_E = \left(\frac{\pi}{\ell}\right)^2 EI\, 10^4$$

P_z : Nominal lateral load [N/mm^2], acting on the stiffener due to stresses σ_x and τ, in the attached plating in way of the stiffener mid span:

$$P_z = \frac{t_p}{s} \left(\sigma_{x\ell} \left(\frac{\pi s}{\ell}\right)^2 + \sqrt{2}\, \tau_1 \right)$$

$\sigma_{x\ell} = \gamma_c \sigma_x \left(1 + \frac{A_s}{s t_p}\right)$ but not but not less than 0

$\tau_1 = \left(\gamma_c |\tau| - t_p \sqrt{R_{eH-p} E \left(\frac{m_1}{a^2} + \frac{m_2}{s^2} \right)} \right) \geq 0$ but not less than 0

m_1, m_2 : Coefficients taken equal to:

m_1 = 1.47, m_2 = 0.49 for $\alpha \geq 2$.

m_1 = 1.96, m_2 = 0.37 for $\alpha < 2$.

w : Deformation of stiffener [mm], taken equal to:

$$w = w_0 + w_1$$

w_0 : Assumed imperfection [mm], taken equal to:

$w = \ell\, 10^{-3}$ in general

$w_0 = -w_{na}$ for stiffeners sniped at both ends, considering stiffener induced failure (*SI*)

$w_0 = w_{na}$ for stiffeners sniped at both ends, considering plate induced failure (*PI*)

w_{na} : Distance [mm], from the mid-point of attached plating to the neutral axis of the stiffener calculated with the effective width of the attached plating b_{eff}.

w_1 : Deformation [mm] of stiffener at midpoint of stiffener span due to lateral load *P*. In case of uniformly distributed load, w_1 is to be taken as:

$w_1 = C_i \frac{|P| s \ell^4}{384\, EI} 10^{-7}$ in general

$w_1 = C_i \frac{5\, |P| s \ell^4}{384\, EI} 10^{-7}$ for stiffener sniped at both ends

c_f : Elastic support provided by the stiffener [N/mm^2], to be taken equal to:

$$c_f = F_E \left(\frac{\pi}{\ell}\right)^2 \left(1 + c_p\right)$$

c_p : Coefficient to be taken as:

$$c_p = \frac{1}{1 + \frac{0.91}{c_{xa}}\left(\frac{12I10^4}{st_p^3} - 1\right)}$$

c_{xa} : Coefficient to be taken as:

$c_{xa} = \left(\frac{\ell}{2s} + \frac{2s}{\ell}\right)^2$ for $\ell \geq 2s$

$c_{xa} = \left(1 + \left(\frac{\ell}{2s}\right)^2\right)^2$ for $\ell < 2s$

6.4.4.4 Stress due to torsional deformation σ_w

6.4.4.4.1 The stress due to torsional deformation σ_w [N/mm^2], is to be taken equal to:

$$\sigma_w = E\, y_w \left(\frac{t_f}{2} + h_w\right) \Phi_0 \left(\frac{\pi}{\ell}\right)^2 \left(\frac{1}{1 - \frac{0.4\, R_{eH-S}}{\sigma_{ET}}} - 1\right)$$

for stiffener induced failure (*SI*).

$\sigma_w = 0$ for plate induced failure (*PI*).

where:

y_w : Distance [mm], from centroid of stiffener cross-section to the free edge of stiffener flange, to be taken as:

$y_w = \frac{t_w}{2}$ for flat bar.

$y_w = b_f - \frac{h_w t_w^2 + t_f b_f^2}{2A_s}$ for angle and bulb profiles.

$y_w = \frac{b_f}{2}$ for Tee profile.

$$\Phi_0 = \frac{\ell}{h_w} 10^{-3}$$

σ_{ET} : Reference stress for torsional buckling, in [N/mm^2]:

$$\sigma_{ET} = \frac{E}{I_P}\left(\frac{\varepsilon\, \pi^2\, I_\omega}{\ell^2} 10^2 + 0.385 I_T\right)$$

I_P : Net polar moment of inertia of the stiffener about point C as shown in Fig.6.4.4.4, as defined in Table 6.4.4.4 [cm^4].

I_T : Net St. Venant's moment of inertia of the stiffener, as defined in Table 6.4.4.4 [cm^4].

I_ω : Net sectional moment of inertia of the stiffener about point C as shown in Fig.6.4.4.4, as defined in Table 6.4.4.4 [cm^6].

ε : Degree of fixation.

$$\varepsilon = 1 + \frac{\left(\frac{\ell}{\pi}\right)^2 10^{-3}}{\sqrt{I_\omega \left(\frac{0.75\, s}{t_p{}^3} + \frac{e_f - 0.5 t_f}{t_w{}^3}\right)}}$$

Table 6.4.4.4 : Moments of inertia

	Flat bars	Bulb, angle and Tee profiles
I_P	$\dfrac{h_w^3 t_w}{3\cdot 10^4}$	$\left(\dfrac{A_w(e_f-0.5t_f)^2}{3}+A_f\, e_f^2\right)10^{-4}$
I_T	$\dfrac{h_w t_w^3}{3\cdot 10^4}\left(1-0.63\dfrac{t_w}{h_w}\right)$	$\dfrac{(e_f-0.5t_f)t_w^3}{3\cdot 10^4}\left(1-0.63\dfrac{t_w}{e_f-0.5t_f}\right)$ + $\dfrac{b_f t_f^3}{3\cdot 10^4}\left(1-0.63\dfrac{t_f}{b_f}\right)$
I_ω	$\dfrac{h_w^3 t_w^3}{36\cdot 10^6}$	$\dfrac{A_f e_f^2 b_f^2}{12\cdot 10^6}\left(\dfrac{A_f+2.6A_w}{A_f+A_w}\right)$ for bulb and angle profiles. $\dfrac{b_f^3 t_f e_f^2}{12\cdot 10^6}$ for Tee profiles.

A_w : Net web area, in [mm^2].
A_f : Net flange area, in [mm^2].

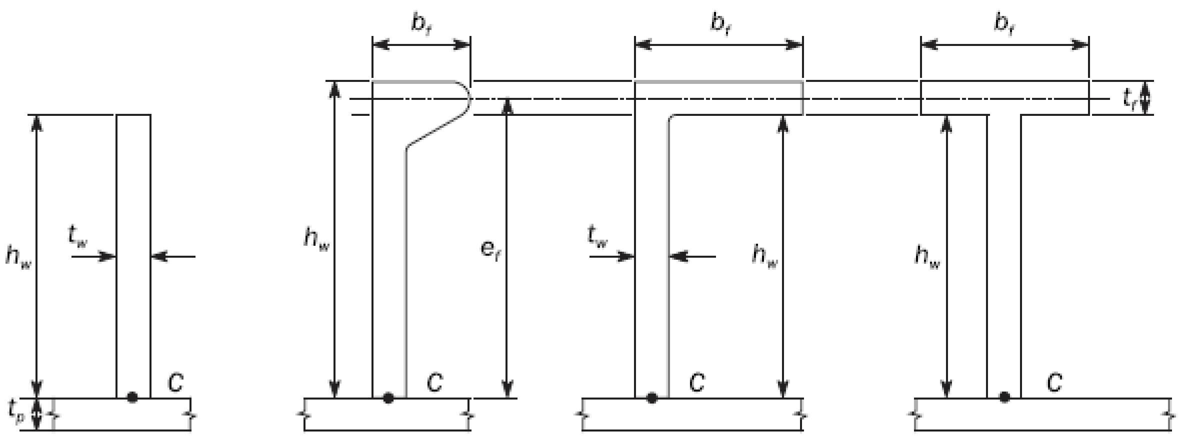


Fig.6.4.4.4 : Stiffener cross sections

Section 7

Ultimate Hull Girder Strength Assessment

This section gives the method of calculation of ultimate hull girder strength as required in 4.7

7.1 General

7.1.1 General Assumptions

7.1.1 The method for calculating the ultimate hull girder capacity is to identify the critical failure modes of all main longitudinal structural elements.

7.1.2 Structures compressed beyond their buckling limit have reduced load carrying capacity. All relevant failure modes for individual structural elements, such as plate buckling, torsional stiffener buckling, stiffener web buckling, lateral or global stiffener buckling and their interactions, are to be considered in order to identify the weakest inter-frame failure mode.

7.1.2 Symbols

7.1.2.1 Refer to table 7.1.2, for description of symbols used in this section.

Table 7.1.2 : Symbols

$I_{y\text{-}net}$:	Net moment of inertia [m^4], of the hull transverse section around its horizontal neutral axis
$Z_{B\text{-}net}$, $Z_{D\text{-}net}$:	Section moduli [m^3], at bottom and deck, respectively,
R_{eH_S}:	Minimum yield stress [N/mm^2], of the material of the considered stiffener.
R_{eH_P}:	Minimum yield stress [N/mm^2], of the material of the considered plate.
$A_{s\text{-}net}$:	Net sectional area [cm^2], of stiffener, without attached plating.
$A_{p\text{-}net}$:	Net sectional area [cm^2], of attached plating.

7.2 Incremental iterative method

7.2.1 Assumptions

7.2.1.1 In applying the incremental-iterative method, the following assumptions are generally to be made:

- The ultimate strength is calculated at hull transverse sections between two adjacent transverse webs.
- The hull girder transverse section remains plane during each curvature increment.
- The hull material has an elasto-plastic behaviour.
- The hull girder transverse section is divided into a set of elements, see 7.2.2.2, which are considered to act independently.

7.2.1.2 According to the iterative procedure, the bending moment M_i acting on the transverse section at each curvature value χ_i is obtained by summing the contribution given by the stress σ acting on each element. The stress σ corresponding to the element strain, ε is to be obtained for each curvature increment from the non-linear load-end shortening curves σ-ε of the element.

7.2.1.3 These curves are to be calculated, for the failure mechanisms of the element, from the formulae specified in 7.2.3. The stress σ is selected as the lowest among the values obtained from each of the considered load-end shortening curves σ-ε.

7.2.1.4 The procedure is to be repeated until the value of the imposed curvature reaches the value χ_F in m^{-1}, in hogging and sagging condition, obtained from the following formula:

$$X_F = \pm 0.003 \frac{M_y}{EI_{y-net}}$$

where:

M_y: Lesser of the values M_{Y1} and M_{Y2}, in [kNm].

$M_{Y1} \; = \; 10^3 \, R_{eH} \, Z_{B\text{-}net}$.

$M_{Y2} \; = \; 10^3 \, R_{eH} \, Z_{D\text{-}net}$.

7.2.1.5 If the value χ_F is not sufficient to evaluate the peaks of the curve $M_{\text{-}\chi}$, the procedure is to be repeated until the value of the imposed curvature permits the calculation of the maximum bending moments of the curve.

7.2.2 Procedure

7.2.2.1 General

7.2.2.1.1 The curve $M_{\text{-}\chi}$ is to be obtained by means of an incremental-iterative approach, summarised in the flow chart in Fig.7.2.2.1.

7.2.2.1.2 In this procedure, the ultimate hull girder bending moment capacity, M_U is defined as the peak value of the curve with vertical bending moment M versus the curvature χ of the ship cross section as shown in Fig.7.2.2.1. The curve is to be obtained through an incremental-iterative approach.

7.2.2.1.3 Each step of the incremental procedure is represented by the calculation of the bending moment M_i which acts on the hull transverse section as the effect of an imposed curvature χ_i.

7.2.2.1.4 For each step, the value χ_i is to be obtained by summing an increment of curvature, $\Delta\chi$ to the value relevant to the previous step χ_{i-1}. This increment of curvature corresponds to an increment of the rotation angle of the hull girder transverse section around its horizontal neutral axis.

7.2.2.1.5 This rotation increment induces axial strains ε in each hull structural element, whose value depends on the position of the element. In hogging condition, the structural elements above the neutral axis are lengthened, while the elements below the neutral axis are shortened, and vice-versa in sagging condition.

7.2.2.1.6 The stress σ induced in each structural element by the strain ε is to be obtained from the load-end shortening curve σ-ε of the element, which takes into account the behaviour of the element in the non-linear elasto-plastic domain.

7.2.2.1.7 The distribution of the stresses induced in all the elements composing the hull transverse section determines, for each step, a variation of the neutral axis position due to the nonlinear σ-ε, relationship. The new position of the neutral axis relevant to the step considered is to be obtained by means of an iterative process, imposing the equilibrium among the stresses acting in all the hull elements on the transverse section.

7.2.2.1.8 Once the position of the neutral axis is known and the relevant element stress distribution in the section is obtained, the bending moment of the section M_i around the new position of the neutral axis, which corresponds to the curvature χ_i imposed in the step considered, is to be obtained by summing the contribution given by each element stress.

7.2.2.1.9 The main steps of the incremental-iterative approach described above are summarised as follows (see also Fig.7.2.2.1):

a) Step 1: Divide the transverse section of hull into stiffened plate elements.

b) Step 2: Define stress-strain relationships for all elements as shown in Fig.7.2.2.1.

c) Step 3: Initialise curvature χ_1 and neutral axis for the first incremental step with the value of incremental curvature (i.e. curvature that induces a stress equal to 1% of yield strength in strength deck) as:

$$\chi_{1.} = \Delta\chi = 0.01 \frac{R_{eH}}{E} \frac{1}{z_D - z_n}$$

where:

z_D: Z coordinate [m], of strength deck at side.

z_n: Z coordinate [m], of horizontal neutral axis of the hull transverse section

d) Step 4: Calculate for each element the corresponding strain, $\varepsilon_i = \chi(z_i - z_n)$ and the corresponding stress σ_i

e) Step 5: Determine the neutral axis z_{NA_cur} at each incremental step by establishing force equilibrium over the whole transverse section as:

$\Sigma A_{i\text{-}net} \; \sigma_i = \Sigma A_{j\text{-}net} \; \sigma_j$ (i-th element is under compression, j-th element under tension).

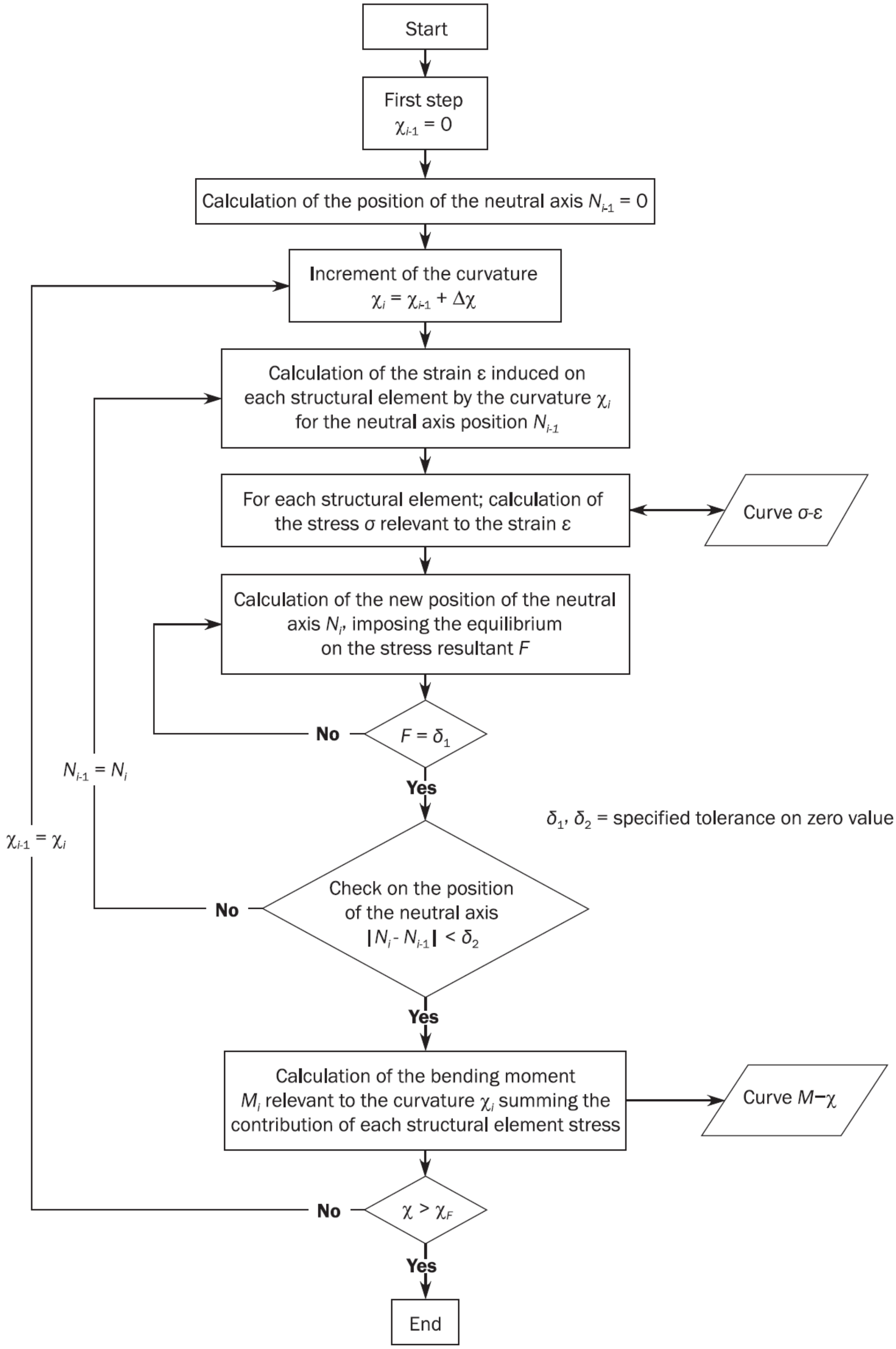


Fig.7.2.2.1 : Flow chart of the procedure for the evaluation of the curve $M_{-\chi}$

f) Step 6: Calculate the corresponding moment by summing the contributions of all elements as:

$$M_U = \sum \sigma_{Ui} A_{i-net} \left| (z_i - z_{NA\_cur}) \right|$$

g) Step 7: Compare the moment in the current incremental step with the moment in the previous incremental step. If the slope in M-χ relationship is less than a negative fixed value, terminate the process and define the peak value M_U. Otherwise, increase the curvature by the amount of $\Delta\chi$ and go to Step 4.

7.2.2.2 Modelling of the hull girder cross section

7.2.2.2.1 Hull girder transverse sections are to be considered as being constituted by the members contributing to the hull girder ultimate strength.

7.2.2.2.2 Sniped stiffeners are also to be modelled, taking account that they do not contribute to the hull girder strength.

7.2.2.2.3 The structural members are categorised into a stiffener element, a stiffened plate element or a hard corner element.

7.2.2.2.4 The plate panel including web plate of girder or side stringer is idealised into a stiffened plate element, an attached plate of a stiffener element or a hard corner element.

7.2.2.2.5 The plate panel is categorised into the following two kinds:

- Longitudinally stiffened panel of which the longer side is in ship's longitudinal direction, and
- Transversely stiffened panel of which the longer side is in the perpendicular direction to ship's longitudinal direction.

a) Hard corner element:

Hard corner elements are sturdier elements composing the hull girder transverse section, which collapse mainly according to an elasto-plastic mode of failure (material yielding); they are generally constituted by two plates not lying in the same plane.

The extent of a hard corner element from the point of intersection of the plates is taken equal to 20 t_{net} on a transversely stiffened panel and to 0.5 s on a longitudinally stiffened panel, see Fig.7.2.2.2.

where:

t_{net} : Net thickness of the plate [mm].

s: Spacing of the adjacent longitudinal stiffener [m].

Bilge, sheer strake-deck stringer elements, girder-deck connections and face plate-web connections on large girders are typical hard corners.

b) Stiffener element:

The stiffener constitutes a stiffener element together with the attached plate.

The attached plate width is in principle:

- Equal to the mean spacing of the stiffener when the panels on both sides of the stiffener are longitudinally stiffened, or
- Equal to the width of the longitudinally stiffened panel when the panel on one side of the stiffener is longitudinally stiffened and the other panel is of the transversely stiffened, see Fig.7.2.2.2.

c) Stiffened plate element:

The plate between stiffener elements, between a stiffener element and a hard corner element or between hard corner elements is to be treated as a stiffened plate element, see Fig.7.2.2.2.

The typical examples of modelling of hull girder section are illustrated in Fig.7.2.2.3.

Notwithstanding the foregoing principle, these figures are to be applied to the modelling in the vicinity of upper deck, sheer strake and hatch coaming.

In case of the knuckle point as shown in Fig. 7.2.2.4, the plating area adjacent to knuckles in the plating with an angle greater than 30 degrees is defined as a hard corner. The extent of one side of the corner is taken equal to 20 t_{net} on transversely framed panels and to 0.5 s on longitudinally framed panels from the knuckle point.

- Where the plate members are stiffened by non-continuous longitudinal stiffeners, the non-continuous stiffeners are considered only as dividing a plate into various elementary plate panels.

- Where the opening is provided in the stiffened plate element, the openings are to be specially considered.

- Where attached plating is made of steels having different thicknesses and/or yield stresses, an average thickness and/or average yield stress obtained from the following formula are to be used for the calculation.

$$t_{net} = \frac{t_{1-net}s_1 + t_{2-net}s_2}{s}$$

$$R_{eH\_P} = \frac{R_{eH\_P1}t_{1-net}s_1 + R_{eH\_P2}t_{2-net}s_2}{t_{net}s}$$

where R_{eH_P1}, R_{eH_P2}, t_{1-net}, t_{2-net}, s_1, s_2 and s are shown in Fig.7.2.2.5

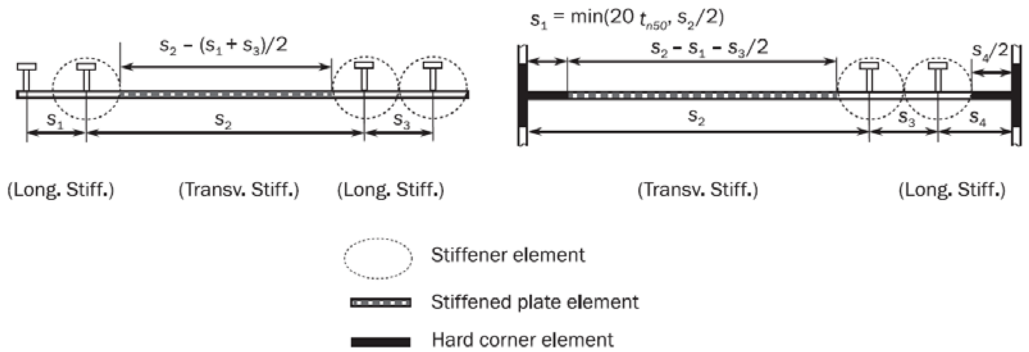


Fig.7.2.2.2 : Extension of the breadth of the attached plating and hard corner element

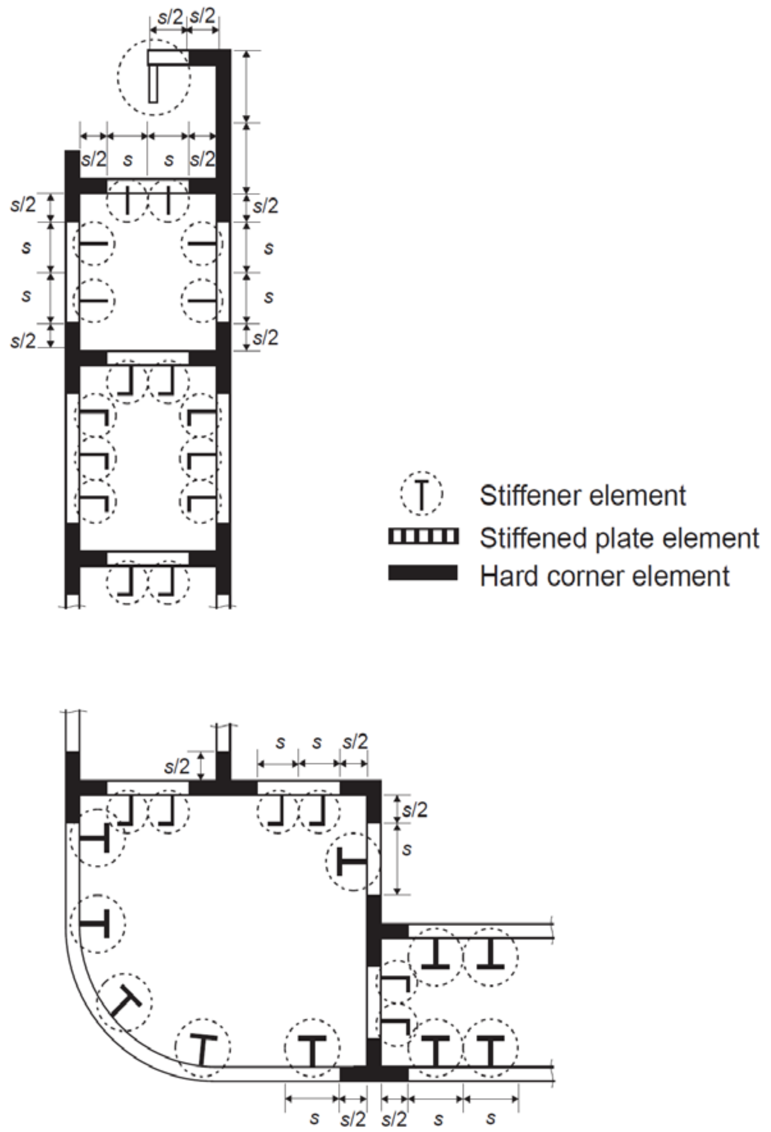


Fig.7.2.2.3 : Examples of the configuration of stiffened plate elements, stiffener elements and hard corner elements on a hull section

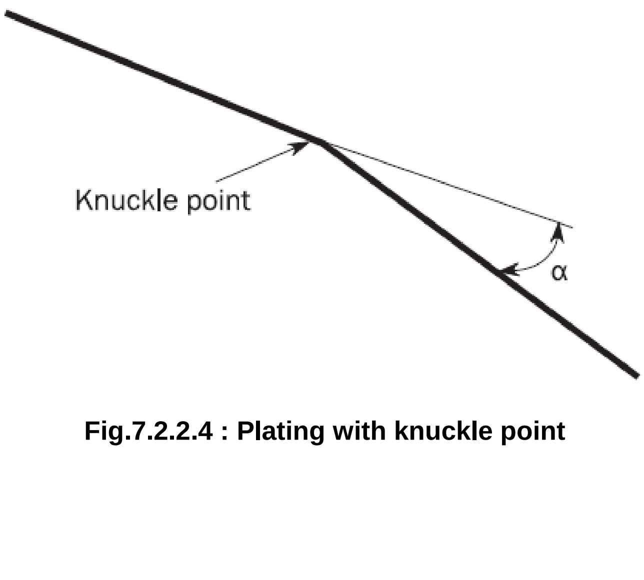


Fig.7.2.2.4 : Plating with knuckle point

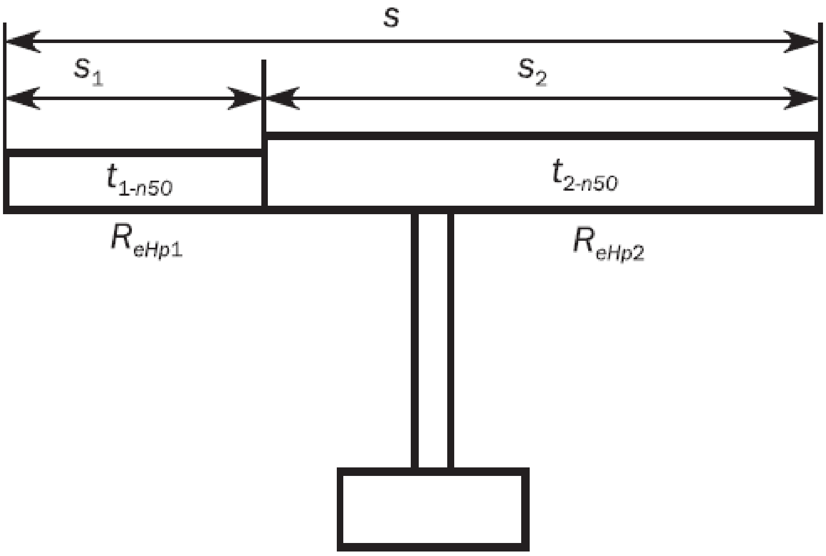


Fig.7.2.2.5 : Element with different thickness and yield strength

7.2.3 Load-end shortening curves

7.2.3.1 Stiffened plate element and stiffener element

7.2.3.1.1 Stiffened plate element and stiffener element composing the hull girder transverse sections may collapse following one of the modes of failure specified in Table 7.2.3.

- Where the plate members are stiffened by non-continuous longitudinal stiffeners, the stress of the element is to be obtained in accordance with 7.2.3.2 to 7.2.3.7, taking into account the non-continuous longitudinal stiffener.

2.3.1.2 In calculating the total forces for checking the hull girder ultimate strength, the area of non-continuous longitudinal stiffener is to be assumed as zero.

- Where the opening is provided in the stiffened plate element, the considered area of the stiffened plate element is to be obtained by deducting the opening area from the plating in calculating the total forces for checking the hull girder ultimate strength.

- For stiffened plate element, the effective width of plate for the load shortening portion of the stress-strain curve is to be taken as full plate width, i.e. to the intersection of other plate or longitudinal stiffener – neither from the end of the hard corner element nor from the attached plating of stiffener element, if any. In calculating the total forces for checking the hull girder ultimate strength, the area of the stiffened plate element is to be taken between the hard corner element and the stiffener element or between the hard corner elements, as applicable.

Table 7.2.3: Modes of failure of stiffened plate element and stiffener element

Element	Mode of failure	Curve σ-ε defined in
Lengthened stiffened plate element or stiffener element	Elasto-plastic collapse	7.2.3.2
Shortened stiffener element	Beam column buckling Torsional buckling Web local buckling of flanged profiles Web local buckling of flat bars	7.2.3.3, 7.2.3.4, 7.2.3.5, 7.2.3.6
Shortened stiffened plate element	Plate buckling	7.2.3.7

7.2.3.2 Elasto-plastic collapse of structural elements (Hard corner element)

7.2.3.2.1 The equation describing the load-end shortening curve σ-ε for the elasto-plastic collapse of structural elements composing the hull girder transverse section is to be obtained from the following formula.

$$\sigma = \Phi R_{eHA}$$

where:

R_{eHA}: Equivalent minimum yield stress [N/mm^2], of the considered element, obtained by the following formula:

$$R_{eHA} = \frac{R_{eH\_P} A_{p-net} + R_{eH\_S} A_{s-net}}{A_{p-net} + A_{s-net}}$$

Φ: Edge function, equal to:

Φ = -1 for ε < -1
Φ = ε for -1 ≤ ε ≤ 1
Φ = 1 for ε > 1

ε: Relative strain, equal to:

$$\varepsilon = \frac{\varepsilon_E}{\varepsilon_Y}$$

ε_E : Element strain.

ε_Y : Strain at yield stress in the element, equal to:

$$\varepsilon_y = \frac{R_{eHA}}{E}$$

7.2.3.3 Beam column buckling

7.2.3.3.1 The positive strain portion of the average stress – average strain curve σ_{CR1} - ε based on beam column buckling of plate-stiffener combinations is described according to the following:

$$\sigma_{CR1} = \phi \sigma_{C1} \frac{A_{s-net} + A_{pE-net}}{A_{s-net} + A_{p-net}}$$

where:

Φ: Edge function, as defined in 7.2.3.2.

σ_{C1}: Critical stress [N/mm^2], equal to:

$$\sigma_{C1} = \frac{\sigma_{E1}}{\varepsilon} \text{ for } \sigma_{E1} \le \frac{R_{eHB}}{2}\varepsilon$$

$$\sigma_{C1} = R_{eHB}\left(1 - \frac{R_{eHB}\varepsilon}{4\sigma_{E1}}\right) \text{ for } \sigma_{E1} > \frac{R_{eHB}}{2}\varepsilon$$

R_{eHB}: Equivalent minimum yield stress [N/mm^2], of the considered element, obtained by the following formula:

$$R_{eHB} = \frac{R_{eH\_p} A_{pEI-net} \ell_{pE} + R_{eH\_S} A_{s-net} \ell_{sE}}{A_{pEI-net} \ell_{pE} + A_{s-net} \ell_{sE}}$$

$A_{pEI-net}$: Effective area [cm^2], equal to:

$$A_{pEI-net} = 10 b_{E1} t_{net}$$

ℓ_{pE}: Distance [mm], measured from the neutral axis of the stiffener with attached plate of width b_{E1} to the bottom of the attached plate

ℓ_{sE}: Distance [mm], measured from the neutral axis of the stiffener with attached plate of width b_{E1} to the top of the stiffener

ε: Relative strain, as defined in 7.2.3.2

σ_{E1}: Euler column buckling stress [N/mm^2], equal to:

$$\sigma_{E1} = \pi^2 E \frac{I_{E-net}}{A_{E-net}\ell^2} 10^{-4}$$

I_{E-net}: Net moment of inertia of stiffeners [cm^4], with attached plate of width b_{E1}

A_{E-net}: Net area [cm^2], of stiffeners with attached plating of width b_E

b_{E1}: Effective width corrected for relative strain, in [m], of the attached plating, equal to:

$$b_{E1} = \frac{s}{\beta_E} \text{ for } \beta_E > 1.0$$

$$b_{E1} = s \text{ for } \beta_E \le 1.0$$

β_E: $$\beta_E = 10^3 \frac{s}{t_{net}} \sqrt{\frac{\varepsilon R_{eH\_P}}{E}}$$

A_{pE-net}: Net area [cm^2], of attached plating of width b_E, equal to:

$$A_{pE-net} = 10 b_E t_{net}$$

b_E: Effective width [m], of the attached plating, equal to:

$$b_E = \left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2} \right) s \text{ for } \beta_E > 1.25$$

$$b_E = s \quad \text{for } \beta_E \le 1.25$$

7.2.3.4 Torsional buckling

7.2.3.4.1 The load-end shortening curve $\sigma_{CR2\text{-}\varepsilon}$ for the flexural-torsional buckling of stiffeners composing the hull girder transverse section is to be obtained according to the following formula:

$$\sigma_{CR2} = \phi \frac{A_{s-net}\sigma_{C2} + A_{p-net}\sigma_{CP}}{A_{s-net} + A_{p-net}}$$

where:

Φ: Edge function, as defined in 7.2.3.2

σ_{C2}: Critical stress [N/mm^2], equal to:

$$\sigma_{C2} = \frac{\sigma_{E2}}{\varepsilon} \text{ for } \sigma_{E2} \le \frac{R_{eH\_S}}{2}\varepsilon$$

$$\sigma_{C2} = R_{eH\_S}\left(1 - \frac{R_{eH\_S}\varepsilon}{4\sigma_{E2}}\right) \text{ for } \sigma_{E2} > \frac{R_{eH\_S}}{2}\varepsilon$$

ε: Relative strain, as defined in 7.2.3.2

σ_{E2}: Euler column buckling stress [N/mm^2], taken as σ_{ET} defined in 6.4.4.4

σ_{CP}: Buckling stress of the attached plating [N/mm^2], equal to:

$$\sigma_{CP} = \left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2} \right) R_{eH\_P} \text{ for } \beta_E > 1.25$$

$$\sigma_{CP} = R_{eH\_P} \text{ for } \beta_E \le 1.25$$

β_E: Coefficient, as defined in 7.2.3.3

7.2.3.5 Web local buckling of stiffeners made of flanged profiles

7.2.3.5.1 The load-end shortening curve $\sigma_{CR3\text{ - }\varepsilon}$ for the web local buckling of flanged stiffeners composing the hull girder transverse section is to be obtained from the following formula:

$$\sigma_{CR3} = \phi \frac{10^3 b_E t_{net} R_{eH\_P} + (h_{we} t_{w-net} + b_f t_{f-net}) R_{eH\_s}}{10^3 s t_{net} + h_w t_{w-net} + b_f t_{f-net}}$$

where:

Φ: Edge function, as defined in 7.2.3.2

b_E: Effective width [m], of the attached plating, as defined in 7.2.3.3

h_{we}: Effective height [mm], of the web, equal to:

$$h_{we} = \left(\frac{2.25}{\beta_w} - \frac{1.25}{\beta_w^2} \right) h_w \text{ for } \beta_w \ge 1.25$$

$$h_{we} = h_w \text{ for } \beta_w < 1.25$$

β_w: $$\beta_w = \frac{h_w}{t_{w-net}} \sqrt{\frac{\varepsilon R_{eH\_s}}{E}}$$

ε: Relative strain, as defined in 7.2.3.2

7.2.3.6 Web local buckling of stiffeners made of flat bars

7.2.3.6.1 The load-end shortening curve $\sigma_{CR4\text{-}\varepsilon}$ for the web local buckling of flat bar stiffeners composing the hull girder transverse section is to be obtained from the following formula:

$$\sigma_{CR4} = \phi \frac{A_{p-net}\sigma_{CP} + A_{s-net}\sigma_{C4}}{A_{p-net} + A_{s-net}}$$

where:

Φ: Edge function, as defined in 7.2.3.2.

σ_{CP}: Buckling stress of the attached plating, in [N/mm^2], as defined in 7.2.3.4.

σ_{C4}: Critical stress [N/mm^2], equal to:

$$\sigma_{C4} = \frac{\sigma_{E4}}{\varepsilon} \text{ for } \sigma_{E4} \le \frac{R_{eH\_S}}{2}\varepsilon$$

$$\sigma_{C4} = R_{eH\_S}\left(1 - \frac{R_{eH\_S}\varepsilon}{4\sigma_{E4}}\right) \text{ for } \sigma_{E4} > \frac{R_{eH\_S}}{2}\varepsilon$$

σ_{E4}: Local Euler buckling stress [N/mm^2], equal to:

$$\sigma_{E4} = 160000\left(\frac{t_{w-net}}{h_w}\right)^2$$

ε: Relative strain, as defined in 7.2.3.2.

7.2.3.7 Plate buckling

7.2.3.7.1 The load-end shortening curve $\sigma_{CR5-\varepsilon}$ for the buckling of transversely stiffened panels composing the hull girder transverse section is to be obtained from the following formula:

$$\sigma_{CR5} = \min\left\{\Phi R_{eH\_P}\left[\frac{s}{\ell}\left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2}\right)^{R_{eH\_P}\Phi} + 0.1\left(1-\frac{s}{\ell}\right)\left(1+\frac{1}{\beta_E^2}\right)^2\right]\right\}$$

where:

Φ: Edge function, as defined in 7.2.3.2.

β_E: Coefficient as defined in 7.2.3.3.

s: Plate breadth [m], taken as the spacing between the stiffeners.

ℓ: Longer side of the plate [m].

7.3 Alternative Methods

7.3.1 General

7.3.1.1 Application of alternative methods is to be agreed by IRS prior to commencement. Documentation of the analysis methodology and detailed comparison of its results are to be submitted for review and acceptance. The use of such methods may require the partial safety factors to be recalibrated.

7.3.1.2 The bending moment-curvature relationship, $M_{-\chi}$, may be established by alternative methods. Such models are to consider all the relevant effects important to the non-linear response with due considerations of:

a) Non-linear geometrical behaviour.

b) Inelastic material behaviour.

c) Geometrical imperfections and residual stresses (geometrical out-of-flatness of plate and stiffeners).

d) Simultaneously acting loads:

- Bi-axial compression.
- Bi-axial tension.
- Shear and lateral pressure.

e) Boundary conditions.

f) Interactions between buckling modes.

g) Interactions between structural elements such as plates, stiffeners, girders, etc.

h) Post-buckling capacity.

i) Overstressed elements on the compression side of hull girder cross section possibly leading to local permanent sets/buckle damages in plating, stiffeners etc. (double bottom effects or similar).

7.3.2 Non-linear finite element analysis

7.3.2.1 Advanced non-linear finite element analyses models may be used for the assessment of the hull girder ultimate capacity. Such models are to consider the relevant effects important to the non-linear responses with due consideration of the items listed in7.3.1.2.

7.3.2.2 Particular attention is to be given to modelling the shape and size of geometrical imperfections. It is to be ensured that the shape and size of geometrical imperfections trigger the most critical failure modes.

Section 8

Load Cases for Finite Element Analysis

8.1 General

8.1.1 The requirements in this section are functional requirements on load cases to be considered on finite element analysis for the structural strength assessment (yielding and buckling).

8.1.2 The procedure for yielding and buckling assessment is to be agreed upon by IRS.

8.1.3 All in-plane stress components (i.e. bi-axial and shear stresses) induced by hull girder loads and local loads as specified in this section are to be considered.

8.1.4 All aspects and principles not mentioned explicitly in this section are to be considered specially.

8.2 Definitions

8.2.1 Global Analysis

8.2.1.1 A Global Analysis is a finite element analysis, using a full ship model, for assessing the structural strength of global hull girder structure, cross deck structures and hatch corner radii.

8.2.2Cargo Hold Analysis

8.2.2.1 A Cargo Hold Analysis is a finite element analysis for assessing the structural strength of the cargo hold primary structural members (PSM) in the midship region.

8.2.3 Primary Structural Members (PSM)

8.2.3.1 Primary structural members are members of girder or stringer type which provide the overall structural integrity of the hull envelope and cargo hold boundaries, such as:

(i) double bottom structure (bottom plate, inner bottom plate, girders, floors)

(ii) double side structure (shell plating, inner hull, stringers and web frames)

(iii) bulkhead structure

(iv) deck and cross deck structure

8.3 Analysis

8.3.1Global Analysis

8.3.1.1 A Global Analysis is to be carried out for ships of length 290 [m] or above. Hull girder loads (including torsional effects) are to be considered. The following methods may be used for Global Analysis:

Method 1: Analysis where hull girder loads only (vertical bending moment, horizontal bending moment and torsional moment) are directly applied to the full ship finite element model

Method 2: Analysis where direct loads transferred from direct load analysis are applied to the full ship finite element model

8.3.2 Cargo Hold Analysis

8.3.2.1 Cargo Hold Analysis is to be carried out for ships of length 150 [m] or above. Local loads such as sea pressure and container loads as well as hull girder loads are to be considered.

8.4 Load principles

8.4.1 Wave environment

8.4.1.1 The ship is to be considered sailing in the North Atlantic wave environment for yielding and buckling assessments. The corresponding vertical wave bending moments are to be in line with Sec 6 and the other hull girder loads are to be taken in consultation/post-agreement with IRS. The corresponding local loads are also to be taken in consultation/post-agreement with IRS.

8.4.2 Ship operating conditions

8.4.2.1Seagoing conditions are to be considered. Harbour conditions and special conditions such as flooded conditions, tank testing conditions may be considered in consultation with IRS.

8.5 Load components

8.5.1 Global Analysis

8.5.1.1 The load components to be considered in Global Analysis are shown in Table 8.5.1.1a).

Table 8.5.1.1a) : Load components to be considered in Global Analysis

	Static Load	Dynamic Load
Method 1	• Still water vertical bending moment • Still water torsional moment	• Wave induced vertical bending moment • Wave induced horizontal bending moment • Wave induced torsional moment
Method 2	• Static sea pressure • Static container loads • Static loads for ballast and fuel oil • Self-weight of hull structure	• Wave induced sea pressure • Dynamic loads for hull structure, containers, ballst and fuel oil

Table 8.5.1.1b) : Load Components to be considered in Cargo Hold Analysis

	Static Load	Dynamic Load
Hull girder loads	• Still water vertical bending moment	• Wave induced vertical bending moment
Local loads	• Static sea pressure • Static container loads • Static loads for ballast and fuel oil[(1)] • Self-weight of hull structure	• Wave induced sea pressure • Dynamic loads for hull structure, containers, ballst and fuel oil
(1) For the minimum set of loading conditions specified in Table 3, all ballast and fuel oil tanks in way of the cargo hold model are to be empty. If additional loading conditions other than those given in Table 3 are considered, ballast and fuel oil loads may be taken into consideration at the discretion of IRS.		

8.6 Loading conditions

8.6.1 Global Analysis

8.6.1.1 Loading conditions to be considered for the Global Analysis are to be in accordance with the Loading Manual (Refer 4.4.6).

8.6.2 Cargo Hold Analysis

8.6.2.1 The minimum set of loading conditions is specified in Table 8.6.2.1. In addition, loading conditions from the Loading Manual are to be considered in the Cargo Hold Analysis where deemed necessary.

Table 8.6.2.1 : Minimum set of loading conditions for Cargo Hold Analysis

Loading condition	**Draught**	**Container weight**	**Ballast and fuel oil tanks**	**Still water hull girder moment**
Full load condition	Scantling Draught	Heavy cargo weight (1) (40ft containers)	Empty	Permissible hogging
Full load condition	Scantling Draught	Light cargo weight (2) (40ft containers)	Empty	Permissible hogging
Full load condition	Reduced Draught(3)	Heavy cargo weight (1) (20ft containers)	Empty	Permissible sagging (minimum hogging)
One bay empty condition(4)	Scantling draught	Heavy cargo weight (1) (40ft containers)	Empty	Permissible hogging

(1) Heavy cargo weight of a container unit is to be calculated as the permissible stacking weight divided by the maximum number of tiers planned.

(2) Light cargo weight corresponds to the expected cargo weight when light cargo is loaded in the considered holds.

- Light cargo weight of a container unit in hold is not to be taken more than 55% of its related heavy cargo weight (see (1) above).

- Light cargo weight of a container unit on deck is not to be taken more than 90% of its related heavy cargo weight (see (1) above) or 17 metric tons, whichever is the lesser.

(3) Reduced draught corresponds to the expected draught amidships when heavy cargo is loaded in the considered holds while lighter cargo is loaded in other holds. Reduced draught is not to be taken more than 90% of scantling draught.

(4) For one bay empty condition, if the cargo hold consists of two or more bays, then each bay is to be considered entirely empty in hold and on deck (other bays full) in turn as separate load cases.

8.7 Wave conditions

8.7.1 Global Analysis

8.7.1.1 Wave conditions presumed to lead to the most severe load combinations due to vertical bending moment, horizontal bending moment and torsional moment are to be considered.

8.7.2 Cargo Hold Analysis

8.7.2.1 The following wave conditions are to be considered:

(i) Head sea condition yielding the maximum hogging and sagging vertical bending moments.

(ii) Beam sea condition yielding the maximum roll motion. This condition may be disregarded for some loading conditions defined in Table 8.6.2.1 where deemed not necessary.

Section 9

Container Stowage and Securing Arrangement

9.1 General

9.1.1 Details of stowage and securing arrangement of containers is to be submitted for approval.

9.2 Stowage arrangement

9.2.1 Containers are generally to be stowed in fore and aft direction in holds, tween decks and on top of exposed decks and hatch covers. The arrangement for securing the containers in position are to be designed on the basis of the most severe distribution of loads which may arise in the container stack.

9.2.2 In general containers are to be assumed to be fully loaded. Where, however, specified loading patterns are proposed, the securing arrangements may be considered on the basis of these loading patterns which are to be clearly indicated on the Cargo Securing Manual to be kept on board.

9.2.3 Where containers certified to higher strength standards are to be incorporated in the stowage arrangement, the container stowage plan is to indicate clearly the locations where these containers are stowed.

9.2.4 Containers stowed on the deck are not to extend beyond the ship's side. Adequate supports are to be provided when they overhang hatch coamings or other deck structures.

9.2.5 Where containers are stowed on the hatch covers, the cover and the hatch coamings are to be additionally strengthened. In addition, the hatch covers are to be effectively restrained against sliding by approved type stoppers or equivalent.

9.2.6 All equipment on deck and in holds essential for maintaining the safety of the ship and which are to be accessible at sea, e.g. fire fighting equipment, sounding pipes etc., are not to be made inaccessible by the containers or their securing arrangement.

9.3 Securing systems

9.3.1 Containers are to be secured generally by any of the following systems:

- Corner lashing devices;
- Rod, wire or chain lashings;
- Buttress, shores or equivalent structural restraint;
- Cell guides.

9.3.2 Local reinforcements are to be fitted as necessary in way of the fittings attached to the ship structure.

9.3.3 When cell guide system is provided, the guides are to be constructed to effectively transmit the loads to double bottom, side structure and bulkheads.

The cell guides are not to be connected to the projections of deck plating edges in way of the hatchways. Any flame cutting or welding is to be avoided on the deck plating in the hatchway corners.

End of Chapter

Chapter 6

Passenger Vessels

Contents

Section

Section 1

General

1.1 Application

1.1.1 The requirements of this chapter apply to sea-going passenger ships intended to carry more than 12 passengers and are supplementary to those given for the main character of class.

1.1.2 The requirements of this chapter also apply to:

a) ferries intended for the carriage of passenger and/or vehicles on a regular scheduled service of short duration; and

b) roll-on roll-off ferries intended to carry passengers, vehicles and cargo in pellet form or in containers and loaded/unloaded by wheeled vehicles.

1.1.3 Ships complying with the requirements of the above will be eligible to be assigned one of the class notations

- **"PASSENGER SHIP";**
- **"FERRY";**
- **"RO-RO FERRY".**

1.1.4 The applicable requirements of SOLAS 1974 regulations and its amendments including SOLAS 1995 and IMO Resolution MSC 47(66), (as on June, 1996) are to be complied with in their entirety except when waived or relaxed by the National Administration.

1.2 Documentation

1.2.1 In addition to the information and plans required in Pt.3, Ch.1, following details are to be submitted:

Stern or bow ramps;

- Bow, stern and side doors;
- Movable decks, if any, including stowage arrangements for portable components;
- Details of deck loadings including wheeled vehicles and trains, as applicable; as well as the fixed securing points and the lashing arrangements for such loads;
- Arrangement of openings on watertight bulkheads.

1.2.2 Following documents are to be submitted for reference:

- 'Damage Control Plan' see Pt.3, Ch.1, Sec.1.5.
- Cargo Securing Manual for wheeled vehicles as per Chapter VI, Regulation 5 of SOLAS 74.

Section 2

Ship Arrangement

2.1 Structural configuration

2.1.1 The structural configuration detailed in Chapter II-1, Part B of SOLAS 74, and amendments as applicable to passenger ships, are to be complied with.

2.1.2 Where a reduced number of bulkheads are envisaged above the bulkhead deck, partial bulkheads and appropriate transverse ring structures are to be fitted to provide equivalent transverse strength.

2.2 Machinery, control and electrical arrangement

2.2.1 In addition to complying with the requirements of Pt.4, as applicable to passenger ships, the following are to be complied with.

2.2.2 Machinery & equipments detailed below are not to be located forward of the collision bulkhead:

- bilge pumps except those specially serving the spaces forward of the collision bulkhead;
- fire pumps;
- emergency source of electrical power;
- any fixed fire-extinguishing system required by Pt.6;
- other emergency installations essential for the safety of the ships.

These equipment are also not to be located within the shaft tunnel or the space containing the forward propeller gland.

2.2.3 In passenger ships constructed on or after 01 July 2010, supplementary lighting is to be provided in all cabins to clearly indicate the exit so that occupants will be able to find their way to the door. Such lighting, which may be connected to an emergency source of power or have a self-contained source of electrical power in each cabin, are automatically illuminated when power to the normal cabin lighting is lost and remain on for a minimum of 30 min.

2.2.4 Every passenger ship with ro-ro cargo spaces is to be provided with supplementary emergency lighting system of adequate illumination in all passenger public spaces and alleyways. These should operate for at least three hours under any condition of heel when all other sources of electrical power have failed. The source of power for the supplementary lighting is to consist of accumulator batteries located within the lighting units and are to be continuously charged. All crew space alleyway, recreational space and every working space that is normally occupied are to be provided with portable rechargeable battery operated lamps unless they are fitted with the supplementary emergency lighting mentioned earlier.

2.3 Fire safety measures

2.3.1 The fire safety measures comprising of structural fire protection, detection and extinction are to comply with the requirements of Pt.6.

2.4 Flooding detection system

2.4.1 A flooding detection system for watertight spaces below the bulkhead deck is to be provided on passenger ships carrying 36 or more persons, constructed on or after 01 July 2010. (Refer to MSC.1/Circ. 1291 “Guidelines for flooding detection systems on passenger ships”).

2.5 System capabilities and operational information after a flooding casualty

2.5.1 Application

Clause 2.5 applies to passenger ships constructed on or after 1 July 2010 to which Pt.6, Ch.7, Sec.4 applies.

*2.5.2 Availability of essential systems in case of flooding damage**

A passenger ship is to be designed so that the systems specified in Pt.6, Ch.7, Cl.4.4 remain operational when the ship is subject to flooding of any single watertight compartment.

* Refer to “Interim explanatory notes for the assessment of passenger ship systems’ capabilities after a fire or flooding casualty” MSC.1/Circ.1369.

2.5.3 Operational information after a flooding casualty

For the purpose of providing operational information to the Master for safe return to port after a flooding casualty, passenger ships constructed on or after 1 January 2014 are to have.

1. Onboard stability computer; or
2. Shore-based support,

based on MSC.1/Circ.1400 "Guidelines on operational information for the masters of passenger ships for safe return to port by own power or under tow ".

Section 3

Hull Structure

3.1 Longitudinal strength

3.1.1 Longitudinal strength calculations are to be carried out in accordance with Pt.3, Ch.5.

For ships with multideck arrangements, the effectiveness of superstructures will be specially considered.

3.2 Bottom structure

3.2.1 All passenger ships are to be provided with a double bottom structure in accordance with SOLAS 74, Chapter II-1, Part B, Regulation 12.

3.2.2 The scantlings of the bottom structure are to comply with Pt.3, Ch.7.

3.2.3 In ships where transfer of loads between deck and bottom is carried out through a series of pillars, the double bottom structure is to be reinforced to avoid high shear and bending stresses due to the concentrated loads transmitted by the pillar system.

3.3 Side structure

3.3.1 The thickness of side shell plating and sides of enclosed superstructures which participate in the longitudinal strength may require to be increased to comply with the buckling requirements given in Pt. 3, Ch.3.

3.3.2 Openings for doors and windows in the side shell and superstructure plating, are to be suitably stiffened. The thickness and material grade of plating in way of large openings will be specially considered.

3.3.3 Where ramp openings are provided on the ship-side, the structure in way is to be adequately strengthened.

3.4 Deck structure

3.4.1 Vehicle decks are to comply with the requirements for wheel loading as given in Pt.3, Ch.9. In addition, the vehicle deck structure is to be also capable of withstanding the concentrated loads coming from the fixed securing points.

3.5 Bulkhead structure

3.5.1 The arrangement and disposition of bulkheads is to be such as to ensure compliance with the subdivision and damage stability requirements of SOLAS 74, Chapter II-1, Part B.

3.5.2 In case of ships fitted with long forward superstructure, the weathertight extension of the forepeak or collision bulkhead is to be in accordance with the requirements of SOLAS 74, Chapter II-1, Part B, Regulation 10 (last amendment 1995).

3.6 Superstructures

3.6.1 The scantlings and arrangements of superstructure of multideck passenger ships will be specially considered in light of the length of the superstructure, alignment of the side walls with the side shell, size of openings on the sides and continuity of internal decks.

Section 4

Openings and their Closing Appliances

4.1 Openings on ship sides

4.1.1 The number of openings on the side shell are to be kept to a minimum compatible with the design and working of the ship. The arrangement, scantlings and efficiency of the means for closing any opening in the shell plating are to comply with the requirements of Pt.3, Ch.12, Sec. 5.

4.1.2 Details of bow doors and inner doors are to be as per Pt.3, Ch.12, Sec.6.

4.1.3 The inboard openings of ash and rubbish chutes, etc. where fitted, are to be provided with efficient covers. If the inboard opening is situated below the bulkhead deck, the cover is to be watertight and, in addition a screw down non-return valve is to be fitted in the chutes above the deepest subdivision load line. The valve is to be controlled from a position above the bulkhead deck and provided with open/shut indicators.

4.1.4 All side scuttles to spaces on the first tier above the bulkhead deck are to be fitted with efficient inside deadlights, so arranged that they can be easily and effectively closed and secured watertight.

4.2 Openings on the deck

4.2.1 All openings on the exposed weather deck are to have coamings of ample height and strength and are to be provided with efficient means for expeditiously closing them weathertight. Freeing ports, open rails and scuppers are to be fitted as necessary for rapidly clearing the weather deck of water under all weather conditions.

4.2.2 In ro-ro passenger vessels arrangements, of all access openings, leading to spaces below the bulkhead deck are to be in accordance with SOLAS 74 Chapter II-1, Part B-2, Regulation 17 and 17-1.

4.3 Watertight integrity above bulkhead deck

4.3.1 All reasonable and practical measures including provision of partial bulkheads and decks if required, are to be taken to limit the entry and spread of water above the bulkhead deck. When partial bulkheads and webs are fitted on the bulkhead deck, above or in the immediate vicinity of main subdivision bulkheads, they are to have watertight connections with the shell and the bulkhead deck so as to restrict the flow of water along the deck when the ship is heeled in a damaged condition.

4.3.2 Open ends of air pipes terminating within superstructure shall be at least 1 [m] above the waterline when the ship heels to an angle of 15 or the max. angle of heel during intermediate stages flooding as determined by direct calculations, whichever is greater.

4.3.3 Where the main vehicle deck is enclosed, all companionways and openings in the deck which lead to spaces below are generally to be protected by steel doors or hatch covers. Approved fire doors may be accepted in lieu of steel doors. The sills or coamings are to be not less than 230 [mm] above the main vehicle deck, with the exception of those leading to machinery spaces which are to have sills or coamings not less than 380 [mm]. Where such openings are to be kept closed while at sea and a permanent notice to this effect is put, the height of sills or coamings may be reduced provided sealing arrangements are adequately improved by sufficient number of clamping devices. Such items as portable plates in the main vehicle deck arranged for the removal of machinery parts, etc., may be arranged flush with the deck, provided they are secured by gaskets and closely spaced bolts at a pitch not exceeding five times the bolt diameters.

4.3.4 Provisions are to be made for efficient drainage of enclosed cargo spaces above the bulkhead deck. The space between the bow door/visor and inner door/ramp is to be adequately drained, either by a bilge suction or by scuppers (both port and starboard) of diameter not less than 50 [mm]. Details of scuppers and discharges are to be as per Pt.3, Ch.13, Sec.4.

End of Chapter

Chapter 7

Tugs

Contents

Section 1

General

1.1 Application

1.1.1 The requirements of this chapter apply to tugs, and are supplementary to those given for the assignment of main characters of class.

1.1.2 Vessels built in compliance with the above requirements will be eligible to be assigned the class notation " **TUG**". Tugs designed and built for anchor handling operations in offshore sites will be eligible to have the class notation **"ANCHOR HANDLING TUG".**

1.1.3 The maximum value of bollard pull [tonnes] measured during bollard pull test will be entered in the Register of Ships as " **BPmax** .... ". In addition, if requested, the continuous bollard pull [tonnes] measured as per the procedure given in Sec.5.2 will be entered in the Register of Ships as "**BPcont** ..... ".

1.2 Documentation

1.2.1 The following additional plans and documents are to be submitted for approval, as applicable.

Anchor handling and laying arrangement:

- A frame / other arrangements.
- Anchor handling winch.
- Supports and foundations for winches and A-frame / other arrangements as applicable.
- Stern roller (stating the maximum load on the stern roller during anchor handling operation).

Towing arrangement

- Maximum and continuous bollard pull and the breaking strength of the tow rope.

Towing hook

- It's attachment and corresponding strengthening of hull structure, slip arrangements.

Towing winch

- Primemover, shafting, coupling details, maximum braking power.

Towing winch seats

- Underdeck strengthening.

Bollard Pull test program

- Items specified in Sec.5.

1.2.2 Additional Certificates of Approval are to be submitted for :-

a) Towing hook with attachments
b) Towline
c) Towing winch.

1.3 Materials

1.3.1 Towing hook including its attachment is to be made of forged steel in accordance with Pt.2, Ch.5 or of special quality carbon and carbon-manganese steel castings in accordance with Pt.2, Ch.4.

Section 2

Hull Arrangement and Strength

2.1 General

2.1.1 The draught T, used for determination of scantlings is not to be taken less than 0.90 D.

2.1.2 The structure in the forebody and afterbody is to be adequately reinforced against forces arising from pushing operations.

2.2 Longitudinal strength

2.2.1 The requirements of Pt.3, Ch.5, Sec.6 regarding loading instruments, are not applicable to tugs.

2.3 Bottom structure

2.3.1 The requirements of Pt.3, Ch.7, Sec.7 regarding strengthening against slamming, are not applicable to tugs.

2.3.2 Structure in way of openings provided for fitment of propulsion units is to be reinforced to ensure the continuity of longitudinal and transverse strength.

2.3.3 Single bottom floors clear of the machinery space may be flanged in lieu of a face plate.

2.4 Side structure

2.4.1 In fore peak space, side stringers supporting vertical peak frames are to be fitted at a spacing not exceeding 2.0 [m].

2.4.2 For harbour tugs engaged in berthing operations, it is recommended to provide a stringer all around the vessel at a suitable height, to provide additional stiffness against contact.

2.4.3 Stern of vessels designed for anchor handling is to meet requirements of 2.4.3 of Chapter 8.

2.5 Deck structure

2.5.1 Foundations of towing winch and towing hook are to be capable of withstanding the breaking strength of the towline without any permanent deformations. The design of structures under these foundations and under heavy duty bollards is to be based on additional loads imposed by the tow line at its breaking strength.

2.6 Machinery casings, emergency exits, scuttles, air pipes, ventilators & bulwark etc.

2.6.1 Exposed machinery casings are generally to be not less than 900 [mm] high above the upper surface of the deck. Proposals of reduced height to facilitate lowering of the towline, will receive individual consideration on the basis of safety against the ingress of water.

The scantlings of the exposed machinery casings are to be 20% more than those required for exposed deckhouses in the same location and at the casing stiffeners are to be connected to beams at both ends.

2.6.2 Emergency exit from the machinery space to the weather deck is to be capable of being used at extreme angles of heel and is to be located on or near the ship's centreline. The coaming height is to be not less than 600 [mm]. The hatch cover is to have hinges arranged athwartships, and is to be capable of being opened and closed weathertight from either side.

2.6.3 Side scuttles are generally not permitted below the main deck except under special consideration when the distance from the lower edge of side scuttles to the maximum waterline is at least 750 [mm], and the scuttles with hinged inside deadlights meeting the requirements of Type A (heavy) scuttles according to ISO Recommendation 1751, are provided. Scuttles on the sides of any superstructures are to be of the same standard.

Fixed lights of skylights on the deck are to have glass thickness appropriate to their location as required for side scuttles, and fitted with hinged deadlight on the weather side.

2.6.4 In the area aft of the tow hook, the air pipes and vent pipes are to be so arranged as to prevent damage from the towline and to provide maximum practicable angle of downflooding. Closing appliances on air pipes on upper deck are to be of automatic type.

2.6.5 The bulwarks are to be sloped inboard to avoid damage due to contact.

2.7 Sternframe, rudder & steering gear

2.7.1 In the case of tugs designed for maximum helm angle more than 35°, the scantlings of the rudder, rudder stock, stern frame and the steering gear will be specially considered.

2.8 Fenders

2.8.1 In addition to the special fendering provided for pushing operations, an efficient fender is to be fitted all around on the ship's side at deck level.

Section 3

Towing Arrangement

3.1 General

3.1.1 The towline is to be in accordance with Pt.3, Ch.15, Sec.3.2.

3.1.2 The position of the towing hook or towing winch is to be carefully selected so as to minimise the heeling moment as well as the risk of girting due to the pull exerted by the tow rope.

3.2 Strength of towing gear and supporting structure

3.2.1 The design and scantlings of the towing hook or towing winch and their supporting structure are to be based on the design load equal to the breaking strength of the largest towline to be used.

3.2.2 The scantlings of all components of towing gear and its supporting structure are to be derived from direct calculations considering all possible directions of the tow rope from port to starboard in horizontal plane as well as in the plane inclined at 45° above the horizontal and the permissible stresses given below:

For towing hook and towing winch

$\sigma_e = 0.9\ \sigma_y$

For towing gear supporting structure

$\sigma_e = 0.85\ \sigma_y$

where,

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2}$$

σ = Normal stress

τ= shear stress

σ_y = yield stress of the material.

For tugs with conventional propellers, alternatively, for the purpose of calculations the range of tow rope angle in the horizontal plane may be considered to be limited to within 30° port to 30° starboard.

3.3 Quick release devices for tow hooks

3.3.1 Towing hook should be provided with an efficient slip arrangement to facilitate release of the towline regardless of the angle of heel and the direction of the towline. The releasing device is also to be operable from the bridge.

3.3.2 Releasing devices may be mechanical, hydraulic or pneumatic type. A releasing device is to be so designed that unintentional slipping is avoided.

3.3.3 Mechanical releasing devices are to be designed so that the required release force does not exceed 150 [N] at the towing hook and 250 [N] on the bridge when the hook is subjected to the design load.

The release rope is to be guided over rope sheaves. Slipping should be possible by downward drawing, using the whole body weight.

3.3.4 For a pneumatic releasing device, a complete mechanical slip device has to be additionally provided.

3.4 Safety devices for towing winches

3.4.1 Towing winch is to be provided with disconnecting coupling operable from the bridge.

3.4.2 The towing winch brakes are to have sufficient static holding capacity which is to be not less than 1.8 times the maximum continuous bollard pull of the vessel. The holding capability should be calculated for the outermost towline layer on the winch drum at which towing will be performed.

3.4.3 It should be possible to release the tension on the winch drum(s) in an emergency and in all operational modes. After an emergency release the winch brakes should revert to normal function without delay. It should also be possible to carry out the emergency release sequence (emergency release/application of brakes) even during a black-out.

3.4.4 Means should be provided to spool the towline effectively on the drum(s).

3.4.5 Towing winch location is to facilitate safe guiding of the tow rope in accordance with load direction.

3.4.6 Winch is to be safely operated from control stands on the bridge and on deck. In case winch drum is not clearly visible from any of the control stands, suitable rope guide is to be provided.

3.4.7 Operating direction of winch drum control levers is to be the same as the direction of motion of the rope. When released, control levers are to return to the stop position automatically. Arrangement to secure control lever in stop position is to be provided.

3.4.8 Mechanism to disengage winch drum from the drive is to be provided.

3.4.9 Arrangement for quick release of the winch drum brake from all control stands is to be provided. After quick release of brake, the winch driving motor is not to start automatically.

3.5 Testing

3.5.1 At manufacturer's works

3.5.1.1 Towing hooks and towing winches completed in all respect, including the quick release devices are to be subjected to a design load as per para 3.2.1 at an approved testing facility.

3.5.1.2 Components of towing hooks and towing winches, subjected to pressure, are to be pressure tested at 1.5 times admissible working pressure or opening pressure of safety valves.

3.5.2 Testing onboard

3.5.2.1 All towing hooks and towing winches along with the quick release devices are to be subjected to bollard pull test as per Sec.5. After bollard pull test quick release devices are to be subjected to an operational trial at no load.

3.5.3 Periodical testing of towing gears

3.5.3.1 The functional safety of towing gear and quick release devices are to be tested by the ship's staff, at least once a month.

3.5.3.2 Following initial testing onboard, towing gears and quick release devices are to be thoroughly examined every two years and subjected to design load at an approved testing facility.

Section 4

Stability

4.1 General

4.1.1 In addition to the general requirements in Pt.3, Ch.1, Sec.1.4, the stability of tugs is to be assessed considering the effect of transverse heeling force caused when the tow rope is not in line with the tug's longitudinal centerline. Compliance with the following criteria is recommended, as a minimum :

(i) The residual area between a righting lever curve and a heeling lever curve developed from 70% of the maximum bollard pull force acting in 90° to the ship length direction is not to be less than 0.09 [m-rad];

The residual areas under the curves are to be calculated from the 1st intercept upto an angle of 40° beyond the first intercept or upto the downflooding angle, whichever is less.

OR

(ii) alternatively, the area under a righting lever curve should not be less than 1.4 times the area under a heeling lever curve developed from 70% of the maximum bollard pull force acting in 90° to ship-length direction.

In this case the areas under the curves are to be calculated from upright condition upto an angle of 40° or the downflooding angle, whichever is less.

The heeling lever curve is to be derived by using the following formula:

$$b_h = 0.7\ TH \cos\theta / 9.81\Delta$$

b_h = heeling arm [m];
T = maximum bollard pull [kN];
H = vertical distance [m] between the towing hook and the centre of the propeller;
Δ = loading condition displacement [t];
θ = angle of heel.

Section 5

Tests and Trials

5.1 Towing gear

5.1.1 In addition to the tests at the manufacturer's works, the towing gear including the towing hook, winch and their emergency release systems are to be tested after installation.

5.2 Bollard pull test procedure

5.2.1 The proposed test programme is to be submitted prior to the testing.

5.2.2 Test for continuous bollard pull is to be carried out with the main engines running at the maximum attainable engine RPM without exceeding the maximum RPM and torque recommended by the engine builder for continuous operation.

5.2.3 The test is to be carried out with the vessel's own propellers only. All auxiliary machinery which are normally driven from the main engine(s) or propeller shaft(s) while towing, are to be connected during the test.

5.2.4 It is recommended that the water depth at test location be not less than 20 [m] within a radius of 100 [m] from the vessel.

5.2.5 The length of the towline, measured between the vessel's stern and the shore bollard, is not to be less than 300 [m].

5.2.6 The test should be carried out at a wind speed not exceeding 5 [m/s] and a current not exceeding 1 [knot] in any direction.

5.2.7 An approved and calibrated load measuring device giving a continuous read-out is to be fitted between the eye of the towline and the bollard. Fitting of a load cell connected to instruments giving a continuous digital read-out and also a graphical record of the bollard pull against time is recommended.

5.2.8 During the test, efficient communication is to be maintained between the vessel and the shore personnel recording the bollard pull.

5.2.9 The vessel is to maintain a fixed course for at least 10 minutes during which the bollard pull is to be recorded.

5.2.10 The pull maintained uniformly for minimum of 10 minutes without any tendency to decline shall be certified as the vessel's continuous bollard pull, subject to a limit of 50% of the breaking strength of the towline supplied.

End of Chapter

Chapter 8

Supply Vessels

Contents

Section

Section 1

General

1.1 Application

1.1.1 The requirements of this chapter apply to supply vessels, and are supplementary to those given for the assignment of main characters of class.

Supply vessels are vessels specially designed and constructed for the transport of specialised stores and cargoes to fixed and mobile offshore installations.

1.1.2 Vessels built in compliance with the above requirements will be eligible to be assigned class notation "**SUPPLY VESSEL**".

Supply vessels which also comply with the requirements for tugs given in Ch.7, will be eligible to be assigned class notation "**TUG / SUPPLY VESSEL**"

Supply vessels designed and built for anchor handling operations in offshore sites in compliance with the requirements of Chapter 7 and this section will be eligible to have the class notation **"ANCHOR HANDLING TUG / SUPPLY VESSEL".**

1.1.3 Supply vessels complying with the requirements for Survival Capability (Floatability in damaged condition) of Ch.3 of the IMO Resolution MSC 235(82) will be eligible to be assigned class notation "**STS**".

1.2 Documentation

1.2.1 The following additional plans and documents are to be submitted for approval, as applicable.

Plans	Also including information on
Separate or independent cargo tanks	foundations, cement and mud system piping arrangement
Anchor handling and laying arrangement	supports and foundations, stern roller
Arrangements for the stowage of deck cargoes	scantlings and support of stow racks

1.2.2 For notation "**STS**" following details are to be submitted for approval:

- Internal watertight integrity plan including details of any tunnels, ducts or pipes etc., in the damage penetration zone and arrangements to prevent progressive flooding;

- Preliminary damage stability calculations;

- Final damage stability calculations (in case the final lightship data compares favourably with the estimated lightship data, the final damage stability calculations need not be submitted);

Section 2

Hull Arrangement and Strength

2.1 General

2.1.1 It is recommended that supply vessels be provided with deep tanks at the wings to provide protection against accidental flooding of the machinery spaces.

2.1.2 Longitudinal fenders are to be fitted on shipsides at upper deck and forecastle deck. In addition, sloping fenders are to be arranged in between the longitudinal fenders.

2.2 Longitudinal strength

2.2.1 The requirements of Pt.3, Ch.5, Sec.6 regarding loading instruments, are not applicable to supply vessels.

2.3 Bottom structure

2.3.1 The flat of bottom in the stern region, if any, is to be additionally stiffened.

2.4 Side structure

2.4.1 The thickness of side shell plating including bilge strake is generally not to be less than :

t = (6.5 + 0.05L) [mm] or 9 [mm], whichever is greater.

2.4.2 The section modulus of the side frames in the tween deck and the forecastle region is not to be less than :

$$Z = 0.0015\ L\ s\ l \quad [cm^3]$$

where,

l = the stiffener span [m]

s = the stiffener spacing [mm].

The section modulus of side frames which are inclined at more than 20 degrees with the vertical, is not be less than 1.25 times the section modulus required as per Pt.3, Ch.8.

The side frames are not to be scalloped and are to be bracketed at both ends.

2.4.3 Stern of vessels designed for anchor handling is to be adequately reinforced. The plating thickness is not to be less than twice that specified in 2.4.1. Where a Stern Roller is fitted, roller and pin connections are to be designed to have a factor of safety of 2.0 to the minimum yield strength of the material under maximum working load.

2.5 Weather decks aft

2.5.1 The scantlings of the weather deck intended to carry deck cargo, are to be based on a pressure 'p' given below :

$$p = p_c + c.\ p_e \qquad [N/mm^2]$$

where,

p_c = pressure due to deck cargo, [N/mm^2] as given in Pt.3, Ch.4, Sec.3.4

p_e = external sea pressure, [N/mm^2] as given in Pt.3, Ch.4, Sec.3.2

c = 1.28 - 0.32.q for q < 4 [t/m^2]

= 0 for q $\geq$ 4 [t/m^2]

q = deck cargo loading, [t/m^2] , but not to be taken less than 1.5 [t/m^2].

2.5.2 Additional local loads on deck, due to anchor handling, specialized cargoes, towing winch, as well as from supports of other heavy components, are to be considered and scantlings increased accordingly.

2.5.3 The thickness of deck plating is not to be less than 8 [mm]. Deck plating adjacent to the stern rollers is to be doubled unless substantial sheathing is provided on deck.

2.5.4 Stow racks of substantial construction are to be provided for protection of deck cargoes. These are to be efficiently attached to the deck structure and adequately supported.

All hatches, air pipes, ventilators, valve controls, etc. are to be located outboard of the stow racks and adequately protected.

2.5.5 The disposition of freeing ports is to be carefully considered to ensure most effective drainage of water trapped in pipe deck cargoes and in way of recesses at the after end of the forecastle. In way of such recesses, appropriate scuppers with discharge pipes led overboard may be required.

2.5.6 Thickness of bulwark plating is not to be less than 7 [mm]. Bulwark stays are generally not to be spaced more than 1.3 [m] apart and the depth of the stay at the lower end is not to be less than 350 [mm]. The stays are to be adequately supported under the deck.

2.6 Superstructures and deckhouses

2.6.1 The thickness of plating forming the unprotected sides and ends of superstructures and deckhouses is to be 1 [mm] higher than that required as per Pt.3, Ch.11, Sec.3.

2.6.2 The section modulus of stiffeners on these bulkheads is to be 50 per cent higher than that required by Pt.3, Ch.11. The stiffeners on front bulkheads are to be bracketed at both ends. The stiffeners on sides and aft end bulkheads are to be bracketed at upper ends and their webs welded to the deck at lower ends.

2.7 Miscellaneous openings and their closing devices

2.7.1 Direct access from the freeboard deck to machinery and other spaces below the freeboard deck is not permitted. As far as practicable, it is to be arranged within the forecastle or above; other equivalent arrangements may be considered.

2.7.2 In deckhouses, windows may be accepted as per the following :

- on aft ends : in second tier above the freeboard deck and higher - Hinged deadlights are required for second tier.

- on sides : in second tier above the freeboard deck and higher - Hinged deadlights are required for second and third tiers.

- on fronts : in third tier above the freeboard deck and higher - Hinged deadlights are required for third tier; for fourth and fifth tiers, portable deadlights stowed adjacent to the windows for quick mounting may be accepted. Deadlights for at least two wheelhouse front windows are to have means for providing clear view.

Deadlights on above mentioned windows are to be of steel and may be hinged externally provided there is easy and safe access for closing.

The dimensions of the windows are to be kept to a minimum, compatible with operational requirements.

2.7.3 Only side scuttles with hinged deadlights will be accepted on the boundaries of superstructures and of deckhouses not mentioned in 2.7.2 above. The side scuttles are to be as per ISO 1751 Type A (heavy) for boundaries of superstructures and fronts of the deckhouses, and Type B (medium) elsewhere.

Section 3

Equipment and Cargo Handling Arrangement

3.1 Anchoring, mooring and towing equipment

3.1.1 For supply vessels, the requirements of Pt.3, Ch.15, Sec.3.2.5 are to be complied with.

3.2 Cement and mud handling systems

3.2.1 General arrangement and systems are to comply with the relevant requirements of Pt.4, Ch.1 to 8 and Pt.6.

3.2.2 Cement, dry mud tanks and the piping systems are, as far as practicable, to be separated from the engine room. Where cement and dry mud tanks are situated in way of engine room, the upper parts of the tanks with hatches, pipe connections and other fittings are to be segregated from the engine room by steel deck and bulkhead. Access doors between the two spaces are to be kept closed while the system is under pressure and suitable signboards are to be provided to that effect.

3.2.3 Cement and dry cargo piping passing through the engine room are to be of substantial thickness and have welded connections in way.

3.2.4 Cement and dry mud tanks are to be certified in accordance with the requirements for pressure vessels.

3.2.5 Liquid mud carried on board is to have a flash point not less than 60°C and the system and arrangement is to comply with the requirements of the fuel oil system. Means for relief of overflow (e.g. through a non- return valve fitted in a branch connection to the air pipe), are to be provided. The sectional area of the overflow pipe is to be at least twice that of the filling pipe.

Section 4

Machinery Arrangement

4.1 Engine exhaust outlets

4.1.1 Engine exhaust outlets are to be located, as high as practicable, above the deck and are to be fitted with spark arrester.

4.2 Steering gear

4.2.1 The steering gear is to be capable of bringing the rudder from 35 degrees on one side to 30 degrees on the other side in 20 seconds, when the vessel is running ahead at maximum service speed.

End of Chapter

Chapter 9

Trawlers and Fishing Vessels

Contents

Section 1

General

1.1 Application

1.1.1 The requirements of this chapter apply to trawlers and fishing vessels, and are supplementary to those given for the assignment of main characters of class.

For the purpose of this chapter, a fishing vessel is a ship used for fishing operations, but not equipped for trawling.

1.1.2 Vessels built in compliance with the above requirements will be eligible to be assigned one of the following class notations:

- **"TRAWLER"**
- **"STERN TRAWLER"**
- **"FISHING VESSEL"**

1.2 Documentation

1.2.1 Following documents are required to be submitted in addition to those specified in Pt.3, Ch.1, Sec.3.

- Winch and crane foundations along with the winch capacities and wire forces.
- Mast and rigging plans.
- Additional deck loads in way of masts, rigging, heavy machinery and equipment.
- Bilge and drainage arrangement from cargo spaces and working areas.
- Details of insulated compartments.

Section 2

Hull Arrangement and Strength

2.1 General

2.1.1 The draught T, used for determination of scantlings is not to be taken less than 0.9D.

2.1.2 All fishing vessels and trawlers are to have pronounced sheer on the forebody or a forecastle.

2.2 Longitudinal strength

2.2.1 The requirements of Pt.3, Ch.5 regarding the loading instruments are not applicable to trawlers and fishing vessels.

2.3 Bottom and side shell structure

2.3.1 The thickness of bottom and side shell plating is not to be less than :

$$t = 6 + 0.06L \text{ [mm]}$$

2.3.2 In the case of vessels engaged in side trawling, the thickness of sheer strake, side shell and bilge strake are to be increased by 30% over a length of not less than 4 [m] abaft the forward gallow leg.

2.3.3 In case of stern trawlers, the thickness of trawl ramp and ramp sides, stern and side shell plating abaft the point where trawling boards are normally taken on board; is to be increased by 30%.

2.3.4 Bulwark plating between the gallows is to be of the same thickness as the adjacent side shell plating and the bulwark is to be supported by stays at every frame.

2.3.5 Bulwark, side shell and transom plating where excessive wear could occur, are to be suitably protected with rubbing bars.

2.3.6 The section modulus of stiffeners in the trawl ramp is not to be less than:

$$Z = 0.015\, l^2 s \quad [cm^3]$$

where,

l,s are the stiffener span [m] and spacing [mm] respectively.

2.4 Deck structure

2.4.1 The thickness of deck plating under the trawl winch, windlass, mast, bollards and gallows is not to be less than:

$t = 7.5 + 0.05L$ [mm]

2.4.2 Adequate scarphing is to be arranged in way of raised decks.

2.5 Bulkhead structure

2.5.1 A collision bulkhead located at a distance greater than 0.08L from the forward end may be considered, provided it is shown that flooding of the forepeak spaces would not cause a deleterious effect on the ship's trim and stability.

2.5.2 Cargo holds designed to carry fish in bulk are to have sufficient number of divisions to ensure that the catch is adequately secured against cargo shifting which could cause dangerous trim or heel of the vessel.

2.6 Hull openings and their closing appliances

2.6.1 Hull openings and their closing appliances are to be according to Pt.3, Ch.12 except as specified otherwise.

2.6.2 Skylights leading to accommodation and machinery spaces below the freeboard deck are to be of substantial construction and capable of being closed weathertight from both sides and be positioned clear of deck working areas. The coaming height of the skylights should be not less than 900 [mm]; lower coaming height may however be considered depending on the practicability of operations and integrity of the weathertightness. Scuttles may be fitted on skylights for accommodation spaces only and are to be of toughened glass fitted with deadlights.

2.6.3 Hatchways are to be fitted with steel coamings, complete with all necessary fittings and covers to ensure weathertight closure. Covers made of materials other than mild steel are to be of equivalent strength. For vessels of L < 24 [m], hatch coaming and/or sill heights of less than 600 [mm] may be accepted depending on the location and size of the opening and the construction details of closing appliances.

2.6.4 Access, loading and discharge hatches on the freeboard deck are to be located along the ship's centreline as far as practicable. Ice scuttles and other small flush type hatches may however, be located away from the centreline, subject to satisfactory means of weathertight closing.

2.6.5 Openings on the deck sides for fishing lines are to be so constructed as to facilitate quick closing of the weathertight cover by one member of the crew. The sill height of such openings is normally not to be less than 1000 [mm]. Side ports, if fitted are to have securing devices with a strength equivalent to the structure to which they are fitted. Suitable notices are to be provided to all such openings stating "TO BE KEPT CLOSED AT SEA WHILE NOT ENGAGED IN FISHING".

2.6.6 Stern trawlers are to be provided with suitable protection such as doors, gates or nets at the top of the stern ramp up to the same height as the adjacent bulwark or guard rail. Where such protection is not in position, a chain or other means of protection are to be fitted across the ramp.

2.6.7 Inboard openings for garbage chutes from factory decks and galley are not to be less than 0.7 [m] above the load waterline and are to be fitted with weathertight covers. The outboard end is to be fitted with watertight screw down non-return valve operable from 1.5 [m] above the deck.

2.7 Masts and rigging

2.7.1 Masts and rigging are to comply with the requirement of Pt.3, Ch.16. Derricks and posts used in conjunction with side trawling are to be approved by IRS.

2.7.2 Where gallows and/or gantries are fitted, they are to be complete with all necessary leads, cleats, hanging blocks, eyebolts, stopper chains and supporting stays, and arranged to allow safe stowage of the trawl doors.

2.7.3 Warping bollards and leads are to be provided with guards as far as practicable and are to be located clear of the working areas.

Section 3

Fish Holds

3.1 Temporary bulkheads in cargo holds

3.1.1 Generally, for vessels of B $\leq$ 6 [m], one longitudinal bulkhead is to be fitted and for vessels of B > 6 [m] two such bulkheads are to be fitted. Spacing of transverse bulkheads in the cargo holds is normally not to exceed 9 [m].

3.2 Refrigerated fish hold

3.2.1 Refrigerated fish hold spaces are to be comply with the requirements of Pt.5, Ch.23, Sec.3.

Section 4

Pumping and Piping Arrangement

4.1 Piping in way of refrigerated chambers

4.1.1 Piping in way of refrigerated chambers is to comply with the requirements of Pt.4, Ch.3 and Pt.5, Ch.23; as applicable.

4.2 Drainage from refrigerated fish hold

4.2.1 Provision is to be made for adequate and continuous drainage of water, oil and brine from inside of all insulated chambers and cooler trays. The drainage arrangement is to comply with the requirements of Pt.4, Ch.3.

4.3 Bilge arrangements of spaces for carriage of fish in bulk

4.3.1 Each fish hold of length less than 9 [m] is to have a bilge well of adequate size suitably located to ensure good drainage of water, oil and brine from the cargo.

Fish holds more than 9 [m] in length are to have minimum two bilge wells.

4.3.2 Separate branch suction lines are to be led from each of the bilge well to the bilge system valve chest in the engine room. The valve chest collecting branch suction lines from the fish holds is to have no connections to other compartments. All valves in the chest are to be screwdown non-return valves and are to be easily accessible. The valve chest is to be directly connected to the largest bilge pump. The second bilge pump should also be connected to the system.

4.3.3 Suitable arrangement is to be made between the bilge suction and the non-return valve to connect a portable water supply to carry out back flushing of each bilge suction.

4.3.4 Tween deck spaces not exposed to the sea and intended to carry loose fish in bulk may be drained into the engine room bilges provided no processing is carried out in that space requiring supply of water. The drainage pipes are normally not to exceed 50 [mm] in diameter and are to have self closing valves on the engine room side.

4.4 Drainage arrangement for working deck

4.4.1 Vessels with processing facilities on the tween deck requiring supply of water for washing down the remains and vessels with side ports or flush deck hatch covers which remain open while fishing at sea, are to have a substantial bilge system similar to the requirements of Sec.4.3. For working decks of length greater than 18 [m], the number of drainage wells will be specially considered.

4.4.2 The volume of each drainage well is not to be less than 0.15 [m^3] and a loose strain-off grating is to be provided on top having clear opening area not less than 3 times the internal sectional area of the bilge suction pipe. The sizes of the bilge suctions are also to be compatible with the capacity of the bilge pumps.

4.4.3 Where only two bilge wells are provided, additional suctions are to be arranged on each side.

4.4.4 Each drainage well is to be provided with an independent bilge suction. The piping system is to be so arranged as to ensure alternative drainage facility from other bilge suctions when any one of the bilge suctions may be clogged.

4.4.5 In addition to the bilge suctions required in 4.4.3 above, outlets from the bilge wells may be led overboard provided the inboard drainage opening on the deck are situated 0.02L (min. 0.7 [m]) above the load waterline. Each such outlet is to have an approved type automatic non-return valve with manual means of closing, operable from a position 1.5 [m] above the deck. In addition, remote closing arrangement is to be provided from the bridge.

The outlet flap opening is to be free from obstructions to prevent clogging by offal that may impair the closability of the flap. Direct overboard discharge may be considered in lieu of the additional suctions required in 4.4.3.

4.4.6 Submerged bilge pumps with rotating knife edge blades may be installed in the bilge wells without the strain-off gratings. The discharge from the submerged pump is to be fitted with screw-down non-return valve capable of operating from 1.5 [m] above the deck. The outboard opening is to be located 0.02L (min. 0.7 [m]) above the load waterline.

4.4.7 The bilge pumping capacity for direct suction from each well is not to be less than 1.25 times the available wash down capacity for the deck wash system, nor less than the requirement of bilge pump capacity as per Pt.4, Ch.3.

4.4.8 The total capacity Q of bilge pumps for drainage of spaces with side ports is not to be less than:

$$Q = 3BA_s \ [m^3/h]$$

where,

A_s = area of the side port [m^2]

The total bilge pump capacity, however, need not exceed

$Q = 0.75\ A_D$ [m^3/h]

where,

A_D = deck area of the compartment fitted with side ports [m^2].

4.5 Alarms and cutouts

4.5.1 Visual and audible alarms are to be fitted on the bridge for the free water on the working deck.

4.5.2 The pumps for the deckwash system are to be capable of being shut down from the bridge in case of emergency.

End of Chapter

Chapter 10

Dredgers

Contents

Section

Section 1

General

1.1 Application

1.1.1 The requirements of this chapter apply to self-propelled or non-self-propelled steel vessels engaged in dredging or reclamation operation and are supplementary to those given for the assignment of main characters of class.

1.1.2 Vessels complying with the above requirements will, in general, be eligible to be assigned one of the following class notations :

- **'DREDGER'**, for dredgers designed to operate wholly or generally for the purpose of raising spoil such as mud, silt, gravel, clay, sand etc. from the bed of sea, rivers, lakes, canals or harbours. The dredged material may be placed in suitably designed holds or similar spaces within the ship.

- **'HOPPER DREDGER'**, for dredgers designed to raise spoil and so arranged that the dredged material may be placed in one or more hoppers (with arrangements to discharge the spoil through doors or valves in the bottom of the ship).

- **'RECLAMATION CRAFT'**, for vessels which receive spoil from a dredger and discharge it ashore.

- **'HOPPER BARGE'**, for non-self-propelled vessels which carry spoil or the dredged material in hoppers within the ship.

- **'SPLIT HOPPER BARGE'**, for vessels similar to hopper barges but with arrangements for discharging the spoil through the bottom of the ship by means of the split hull, separated at the hinges using actuating devices.

1.1.3 In addition to the above notations, appropriate descriptive notes may be entered in the Register Book to indicate the type of dredging or reclamation craft (e.g, 'TRAILING SUCTION DREDGER', 'CUTTER SUCTION DREDGER', 'BUCKET DREDGER', 'GRAB DREDGER' etc.).

1.1.4 Bucket dredgers and non-propelled vessels will, in general, be assigned unrestricted service notation only after special consideration.

1.2 Documentation

1.2.1 In addition to the documents required as per Pt.3, Ch.1, Sec.3, the following details are to be submitted.

- General arrangement plan, showing also the arrangement of the dredging equipment.

- Longitudinal and transverse hopper bulkheads, with information regarding density of the spoil and height of overflow.

- Arrangement and scantlings of substructures attached to or integrated into main structural members, such as gantries, gallows, dredging machinery and pumps, hopper, doors and their operating gear, positioning equipment, other dredging equipment and devices and their seats.

1.3 Statutory requirements

1.3.1 Attention is drawn to the special requirements imposed by National Authorities involving loading limitations and stability requirements. Certain types of dredge material with thixotropic properties can cause shifting of spoil within the spoil spaces, resulting in undesirable changes in trim or angles of heel. This can lead to dangerous situations in ships with closed top spaces.

Section 2

Hull Arrangement and Strength

2.1 General

2.1.1 While determining the principal dimensions of dredgers, local structures and deviations from the principal design dimensions associated with the attachment of the dredging gear, are to be ignored.

2.1.2 Where freeboards less than minimum freeboards are assigned, the length L, draught T and block coefficient C_b are to be determined considering this freeboard.

2.2 Longitudinal strength

2.2.1 For dredgers and other reclamation craft, the longitudinal strength requirements apply as per Pt.3, Ch.5.

2.3 Bottom structure

2.3.1 Where hopper doors are fitted on the vessel's centreline or where there is a centreline well for dredging gear (bucket ladder, suction tube etc.), a plate strake is to be fitted on each side of the well or door opening. The width of this strake is not to be less than 50% of the rule width of the flat keel and thickness not less than that of the rule flat keel.

The same applies where the centreline box keel is located above the base line at such a distance that it cannot serve as a docking keel. In addition, brackets are to be fitted at the longitudinal bulkheads of dredging wells and hopper spaces. These brackets are to extend to the adjacent longitudinals and longitudinal bulkhead stiffeners. Where the spacing of bottom transverses is less than 2.5 [m], one such bracket is to be fitted and for greater spacings, two such brackets are to be fitted. The thickness of the brackets is not to be less than the web thickness of the adjacent bottom transverses. The free edge of the brackets is to be stiffened. Where longitudinal bulkheads and the side shell are framed transversely, the brackets are to be fitted at every frame and are to extend to the bilge.

2.3.2 The corners of hopper door openings and of dredging gear wells generally are to comply with the requirements of Pt.3, Ch.5, Sec.5. The structural details and welded connections in this area are to be designed with particular care.

2.3.3 In transversely framed single bottoms, the height of floors in spaces abreast of hoppers or centreline dredging wells, is to be calculated as per Pt.3, Ch.7 using the actual breadth in these spaces (with a minimum of 0.4B) in place of B.

Floors, longitudinal girders etc. below dredging machinery and pump seats are to be adequately designed for the additional loads.

Where floors are additionally stressed by the reactions of the pressure required for closing the hopper doors, their section modulus and their depth are to be increased accordingly.

Floors in line with the hopper lower cross members fitted between hopper doors are to be connected with the hopper side wall by brackets. The free edge of the brackets is to be stiffened.

2.3.4 In longitudinally framed single bottoms, the spacing of bottom transverses generally is not to exceed 3.6 [m]. Section modulus and web cross sectional area are to be increased by 10% and 20% respectively over that required by Pt.3, Ch.7.

The bottom transverses are to be stiffened by means of flatbar stiffeners, at every longitudinal, of depth equal to the depth of the bottom longitudinals; however, it need not exceed 150 [mm].

2.3.5 Double bottoms need not be fitted in way of the spoil spaces.

Where it is intended to unload the spoil by means of grabs and a double bottom is fitted in way of spoil spaces, plate floors are to be fitted at each frame in case of transverse framing system.

2.3.6 On non-self-propelled dredgers and on self-propelled dredgers with restricted service notation, strengthening of the bottom forward in accordance with Pt.3, Ch.7, Sec.7 need not be provided.

2.3.7 The flat bottom plating of swim ends is to have a thickness not less than that of the rule bottom shell plating amidships, up to 500 [mm] above the maximum load waterline.

2.3.8 Unless specified otherwise, non-self-propelled dredging and reclamation crafts are considered to operate while aground.

In such cases, the bottom structure is to be additionally strengthened as follows:

The thickness of the bottom shell plating is to be increased by 20% above the value required as per Pt.3, Ch.7; however, it is not to be less than 8 [mm].

In transversely framed single bottom construction, floors are to be fitted at every frame, with vertical buckling stiffeners spaced not more than 1.2 [m] apart.

Where the single bottom is longitudinally framed, the spacing of the bottom transverses is not to exceed 1.8 [m]. The webs are to be stiffened to withstand buckling. Side girders, spaced not more than 2.2 [m] apart, are to be provided. The section modulus of the bottom longitudinals is to be increased by 50%, over that required by Pt.3, Ch.7.

In double bottom construction, the requirements as specified for single bottoms, are to be applied analogously.

2.4 Hopper and well structure

2.4.1 The thickness 't' of the boundaries of hopper spaces and wells is to be not less than :

$$t = \frac{s\sqrt{p}}{2\sqrt{\sigma}} + t_c \ \ [mm]$$

or,

t = (5.5 + 0.04L) [mm], whichever is greater.

where,

$p = 0.01\ \rho H$ [N/mm^2]

H = distance from the load point to the upper edge of overflow [m].

ρ = density of the spoil [t/m^3], but not to be taken less than 1.2 [t/m^3].

2.4.2 Section modulus of stiffeners of boundaries of hopper and well spaces are to be as per the requirements of tank bulkheads given in Pt.3, Ch.10 using the pressure given in Sec.2.4.1.

2.4.3 In general, the strength of longitudinal bulkheads of hopper spaces and wells is to be at least equal to that of the ship's sides.

The top and bottom strakes of the longitudinal bulkheads are to be extended through the end bulkheads, or else scarphing brackets are to be fitted in line with the bulkheads in conjunction with strengthenings at deck and bottom.

Where the length of wells does not exceed 0.1 L and where the wells and/or ends of hopper spaces are located beyond 0.6L amidships, special scarphing may not be required.

2.4.4 In vessels fitted with hopper doors, lower cross members are to be fitted between the doors at spacing generally not exceeding 3.6 [m].

The depth of the cross members is not be less than 2.5 times the depth of floors as per Pt.3, Ch.7, Sec.5. The web plate thickness is not to be less than the thickness of the side shell plating. The top and bottom edges of the cross members are to be fitted with face plates. The thickness of the face plates is to be at least 50% greater than the Rule web thickness.

Vertical stiffeners spaced not more than 900 [mm] apart are to be fitted on the webs.

Where the lower cross members are constructed as watertight box girders, the scantlings are not to be less than required by Sec.2.4.1. The top plate is to be increased in thickness by at least 50%.

2.4.5 The transverse bulkheads at the ends of the hoppers are to extend the full breadth of the vessel.

2.4.6 Wash bulkheads or transverse ring structure is to be provided in the wing spaces abreast of the hopper, in line with the lower cross members.

Upper cross members are to be fitted at deck level in line with the ring structure, which are to be supported by means of pillars at the box keel, if fitted. The scantlings of the upper cross members are to based on the actual loads arising from hopper door supporting arrangements. The maximum reactions of hydraulically operated rams, where fitted for hopper door operations, are to be taken as the actual load.

2.4.7 On bucket dredgers, the ladder wells are to be isolated by transverse and longitudinal cofferdams at the bottom, of such size as to prevent the adjacent compartments from being flooded in case of any damage to the shell by dredging equipment and dredged objects.

2.5 Box keel structure

2.5.1 The scantlings of the bottom plating of box keel are to be as follows:

Where the box keel can serve as a docking keel, the requirements for flat plate keels apply.

In other cases, the requirements for bottom shell plating apply.

2.5.2 The remaining plating of the box keel are to be as follows :

- Outside the hopper space, the requirements for bottom shell plating apply.

- Within the hopper space, the requirements for hopper space plating as per 2.4.1 apply. The thickness of the upper portion particularly subjected to damage is to be increased by at least 50%.

2.5.3 Box keel plating is to be adequately stiffened in consonance with the adjoining hopper well structure.

2.5.4 Plate floors are to be fitted within the box keel in line with the web frames as per 2.4.6 to ensure continuity of strength across the vessel.

2.5.5 The ends of the centreline box keel are to be effectively scraphed to the vertical keels or equivalent structure at the ends of the hopper spaces.

Section 3

Miscellaneous

3.1 Equipment

3.1.1 The requirements for equipment of non-self-propelled dredgers are the same as that for barges.

3.1.2 Considering rapid wear and tear, it is recommended that the anchor chain cables, where additionally employed for positioning of the vessel during dredging operations, be increased in size.

3.2 Rudders

3.2.1 In the case of bucket dredgers having bucket ladders at their stern, the ship's rudders are to be kept well clear of the buckets to minimize the possibility of damage to the rudders by large objects that may be dredged up.

3.3 Bulwark and overflow arrangement

3.3.1 Bulkwarks are not to be fitted in way of hoppers where the hopper weirs discharge onto the deck instead of into enclosed overflow trunks. Even where overflow trunks are provided, it is recommended not to fit bulwarks. Adequate protection for crew is to be provided by suitable alternate means in such cases.

However, if bulkwarks are fitted, freeing ports are to be provided throughout their length which should be of sufficient width to allow undisturbed overboard discharge of any spoil spilling out of the hopper in the event of rolling.

3.3.2 Dredgers without restricted service notation, are to be fitted with overflow trunks on either side, suitably arranged and of sufficient size, to permit safe overboard discharge of excess water during dredging operations.

The construction is to be such as not to require cutouts at the upper edge of the sheer strake. Where overflow trunks are carried through the wing compartments, they are to be arranged such as to pierce the sheer strake at an adequate distance from the deck; and also from discontinuities such as breaks of superstructure.

3.3.3 Dredgers with restricted service notation may have overflow arrangements which permit discharge of excess water during dredging operations onto the deck.

3.4 Scuppers, sanitary discharges and side scuttles

3.4.1 In all areas where mechanical damage is likely (due to barges coming alongside), all side scuttles, scuppers and discharges including their valves, controls and their indicators are to be well protected. Special attention is to be paid to the possibility of scuppers becoming blocked by sand and other spoil that may spill on to the deck and other areas being drained.

3.5 Ladder wells

3.5.1 Where the ladder well length exceeds 1.5 times the width of deck remaining on each side of the well, cross connections of adequate strength are to be provided in the region of the free ends, unless alternative arrangements are made to avoid high stress concentrations at the inboard ends of the well.

Section 4

Self-Unloading Barges

4.1 General

4.1.1 The requirements of this section apply to self-unloading barges, the port and starboard portions of which are hinged at the hopper end bulkheads to facilitate rotation around the longitudinal axis, when the bottom is to be opened.

4.2 Longitudinal strength

4.2.1 Longitudinal strength requirements given in Pt.3, Ch.5 are to be applied to self-unloading barges in sailing conditions (hull closed).

Additional calculations for the split hull condition (while unloading) are to be carried out as follows:

4.2.2 The combined stress at any point on the cross section of one half hull, is to be determined according to the formula:

$$\sigma = \left(\frac{M_{Y`}}{Z_{Y`}} + \frac{M_{Z`}}{Z_{Z`}} \right) x 10^3 \ [\mathrm{N/mm^2}]$$

where,

$M_{Y`} = \pm M_Y \cos \alpha \pm M_Z \sin \alpha$ [kN-m]

$M_{Z`} = \pm M_Y \sin \alpha \pm M_Z \cos \alpha$ [kN-m]

M_Y, M_Z = Total bending moments (i.e. still water + wave components) on one half of the hull in the vertical and horizontal directions, respectively. For calculation of M_Y and M_Z see Sec.4.2.3 and Sec.4.2.4.

α = the angle between the usual horizontal and vertical axis system (Y-Y and Z-Z) and the principal inertia axis system (Y'-Y' and Z'-Z') See Fig.4.2.2.

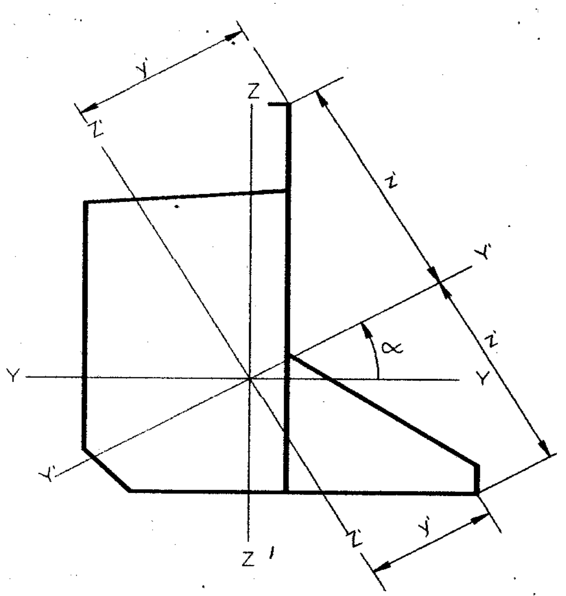


Fig.4.2.2 : Principal inertia axis system.

$$\propto = 0.5 \tan^{-1} \left(\frac{2I_{yz}}{I_{zz} - I_{yy}} \right)$$

I_{YZ} = product of inertia of the cross section with respect to the axis Y-Y and Z-Z [cm^4].

I_{YY}, I_{ZZ} = moment of inertia of the cross section with respect to the axis Y-Y and Z-Z, respectively [cm^4].

$Z_{Y'}$, $Z_{Z'}$ = modulus of section with respect to the principal inertia axes Y'-Y' and Z'-Z' [cm^3].

$= \frac{I_{Y`Y`}}{z`}$ and $\frac{I_{Z`Z`}}{y`}$ respectively. See Fig.4.2.2.

4.2.3 The total vertical bending moment acting on one half of the hull, M_Y is given by:

$M_Y = M_{Y1} + M_{Y2}$ [kN-m]

where,

M_{Y1} = 50% of the vertical still water bending moment determined for the whole hull for the most unfavourable distribution of cargo and consumables.

M_{Y2} = 50% of the vertical wave bending moment as per Pt.3, Ch.5, Sec.2.2.

4.2.4 The total horizontal bending moment acting on one half of the hull, Mz is given by:

$M_Z = M_{Z1} + M_{Z2}$ [kN-m]

where,

M_{Z1} = horizontal still water bending moment due to the horizontal pressure difference between the external hydrostatic pressure on the side shell and the spoil pressure on the hopper bulkhead; which may be taken as:

$M_{Z1} = P \,.\, l_{ho} (2l_h - l_{ho})/8$ [kN-m]

where,

l_h = distance [m], between the hinges

l_{ho} = length of hopper [m]

P = net horizontal loading [kN/m] along the length of the hopper which may be approximated as $0.5\ g_o\ (\rho H^2 - 1.025T^2)$

H = height of the spoil [m], from base line to the top of overflow

ρ = design density of the spoil [t/m^3]

M_{Z2} = horizontal wave bending moment which may be taken as:

$M_{Z2} = 0.286\ R_s\ C_w\ (T - 0.143\ C_w)\ l_h^2$ [kN-m]

C_w, R_s = As given in Pt.3, Ch.4.

4.2.5 The hull girder bending stress, in the split hull condition, calculated as per Sec.4.2.2 is not to exceed σ_L as given below:

σ_L = 175/k within 0.4L amidships

= 125/k within 0.1L from ends

Between the specified regions, σ_L is to be obtained by linear interpolation.

4.3 Hinge arrangement

4.3.1 The forces acting on the hinges, actuating mechanisms and locking devices are to be determined by direct calculations, taking into consideration, the static and dynamic forces acting on the hulls and their respective locations.

A typical arrangement of hinges and mechanisms together with the associated static loads is shown in Fig.4.3.1. In general, the aft and forward hinge assemblies are assumed to share the loads equally.

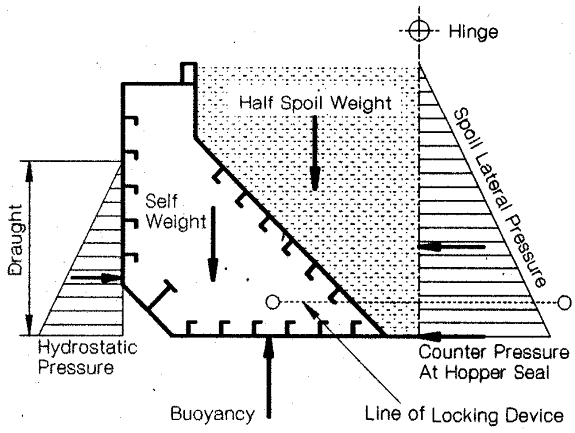


Fig.4.3.1 : Forces acting on split hull.

4.3.2 All elements of the hinge and its associated structure are to be such that the following permissible stress values are not exceeded:

bending stress, $\sigma_b \leq 90/k$ [N/mm^2]

shear stress, $\tau \leq 55/k$ [N/mm^2].

4.3.3 Efficient locking devices of adequate strength are to be provided to prevent the accidental separation of the hulls due to ship motions and vibrations.

4.3.4 Hinge seatings, ram anchorages and locking devices are to be effectively integrated into the local structure and suitably reinforced.

End of Chapter

Chapter 11

Barges and Pontoons

Contents

Section 1

General

1.1 Application

1.1.1 The requirements of this chapter apply to manned or unmanned barges and pontoons and are supplementary to those given for the assignment of main characters of class.

Barges are non-self propelled vessels designed and constructed for carriage of dry cargoes in holds or liquid cargoes in tanks.

Pontoons are non-self propelled vessels designed and constructed for carriage of non-perishable cargoes or equipment on deck.

1.1.2 Vessels built in compliance with the above requirements will be eligible to be assigned class notations " **BARGE** " or " **PONTOON** ", as appropriate.

Barges and pontoons for special purpose or for carriage of specialised cargoes are also to comply with the requirements of relevant Chapters of Pt.5, and such vessels would be eligible for assignment of additional or appropriately modified class notations e.g "**OIL BARGE", "SHIPBORNE BARGE", "BARGE FOR LIQUEFIED GASES ", " CRANE PONTOON** " etc.

Barges and pontoons intended to be operated only on agreed areas or conditions, will be individually considered for service restriction notations as per Pt.1, Ch.1, Sec.2. In particular, the ' Shipborne barges ' will normally be considered for notation 'Restricted Service'.

1.2 Documentation

1.2.1 The following additional plans and documents are to be submitted for approval, as applicable.

- Towing arrangement and details of towing brackets, bollards and other fittings with under deck stiffening.

- Details of structure and fittings, if any, to which deck cargo securing lashings etc. are attached.

- Details of arrangements for lifting fully loaded shipborne barges.

- In case of pusher tugs or integral tug/barge systems or combination units comprising many modules, details of the connecting elements, attachments and supporting structures.

Section 2

Hull Arrangement and Strength

2.1 General

2.1.1 Where a rudder is not fitted, the Rule length, L, is to be taken as 97% of the length of the load waterline at draught T.

In case of pusher tug/barge units with rigid connections, the Rule length, L, is to be based on the combined length of the tug and barge.

2.2 Longitudinal strength

2.2.1 The requirements of Pt.3, Ch.5, Sec.6 regarding loading instruments are not applicable to barges and pontoons.

2.2.2 The hull section modulus may be 5% less than that required by Pt.3, Ch.5, Sec.3.3.

2.2.3 For special harbour conditions, (e.g. shipborne barge fully loaded at crane or transient conditions during loadout of offshore jackets), the wave bending moment M_w and wave shear force Q_w may be neglected, provided the longitudinal bending and shear stresses in these loading conditions are limited to 145/k [N/mm^2] and 100/k [N/mm^2] respectively.

2.3 Bottom structure

2.3.1 For barges and pontoons of L < 90 [m] having no rise of floor, the keel plate thickness may be same as adjacent bottom shell.

2.3.2 On hard chine vessels, where a solid round bar is provided at the knuckles, the diameter of round chine bar is not to be less than three times the bottom plate thickness.

2.4 End construction

2.4.1 Flat bottom areas in way of raked fore ends are to be strengthened according to Pt.3, Ch.7, Sec.7.

2.4.2 In case of vessels having no definite "fore" or "aft", the collision bulkhead and strengthening of bottom forward are to be provided at both ends.

2.5 Truss arrangements

2.5.1 A truss is a system of internal framing members comprising deck and bottom girders in association with regularly spaced stanchions and diagonal bracings inclined at about 45 degrees with the horizontal, in each space between the stanchions.

2.5.2 The scantlings of platings, stiffeners and girders are not to be less than the general requirements given in Pt.3, except as specified in 2.5.3. below.

2.5.3 The section modulus of bottom girders is not to be less than that required by Pt.3, Ch.7, Sec.5, taking the value of the coefficient 'm' as 6.

The section modulus of deck girders is not to be less than that required by Pt.3, Ch.9, Sec.5, taking the value of the coefficient 'm' as 8.

2.5.4 The scantlings of stanchions are to be based on the external sea pressure on bottom or the static cargo load on deck, whichever is higher; and the buckling requirements given in Pt.3, Ch.3, Sec.6. Stanchions in tank spaces are also to be checked for tension caused by internal pressure.

2.5.5 The cross sectional area of diagonals may be approximately 50% of that of the adjacent stanchion.

Section 3

Pushing, Towing - Devices and Connecting Elements

3.1 General

3.1.1 Devices for pushing and towing of linked barges as well as the elements connecting the modular units are to be adequately dimensioned for the acting external forces calculated considering all possible load combinations. Towing gear, brackets and bollards are to be adequately dimensioned for the estimated towing pull considering the displacement and towing speed.

3.1.2 The scantlings of these devices and elements as well as their supporting structures are to be based on following permissible stresses :

bending and normal stress $\sigma = 100/k$ [N/mm^2]

shear stress $\tau = 60/k$ [N/mm^2]

equivalent stress,

$\sqrt{\sigma^2 + 3\tau^2} = 120/k$ [N/mm^2].

Section 4

Machinery and Electrical Installation

4.1 General

4.1.1 Machinery and electrical installations, when provided are to comply with the requirements of Pt.4.

End of Chapter

Chapter 12

Floating Dry Docks

Contents

Section

Section 1

General

1.1 Application

1.1.1 The requirements of this chapter apply to steel floating docks of the types defined in 1.1.2. Other design configurations would be specially considered.

1.1.2 The requirements apply directly to floating docks of the following types:

a) **Caisson type**, in which the bottom caisson and both wing walls are continuous and inseparable.

b) **Pontoon type**, in which the wing walls are continuous and the bottom is formed of non-continuous pontoons. The pontoons may be either permanently attached to the wing walls or may be detachable.

1.1.3 The docks built in compliance with the above requirements will be eligible to the assigned the class notation “FLOATING DOCK”. For special types and configurations of floating docks not covered in 1.1.2, appropriate additional notations may be assigned, if necessary.

1.2 Documentation

1.2.1 The following plans are to be submitted for approval:

- General arrangement
- Transverse section at mid-length
- Structural plan of wing walls, bottom caisson or pontoons
- Structural plan of top deck, safety deck and bulkheads.
- Stability calculations
- Pumping arrangements
- Machinery and electrical plans
- Fire extinguishing systems

1.2.2 The following information is to be submitted:

a) Required lifting capacity (W).

b) Length of shortest contemplated ship having a docking weight equal to the required lifting capacity.

c) The maximum draught of the vessel when entering the dock. Also maximum associated dock submergence draught.

d) Estimated dock lightweight, its main components and distribution.

e) Depth of rest water.

f) Depth of keel and side blocks.

g) Hydrostatic curves

h) Tank arrangements showing maximum service heads and heights of overflow pipes and air pipes.

i) The hydrostatic head assumed for the design of boundary bulkheads separating adjacent ballast tanks. It is equal to the maximum allowable difference between the filling levels of adjacent ballast tanks. This head should be included in the dock operating instructions.

j) Operating manual including ballasting manual.

k) Details of operating site and method of dock securing

l) Full details of the type and proposed arrangement of deflection monitoring equipment.

m) Particulars of indicating system for tank water level and draughts

n) Details of the mooring attachments to the dock structure.

o) Coating specifications of external structure and tanks.

1.3 Definitions

1.3.1 General

1.3.1.1 The lifting capacity "W" of the dock is equal to the displacement [t] of the heaviest ship that the dock is designed to lift in normal service.

1.3.1.2 The light displacement includes the structural weight of the dock complete with all machinery, crane(s), equipment, fresh water, fuel oil for the use of the dock, compensating ballast water (see 1.3.1.9), and rest-water (see 1.3.1.8).

1.3.1.3 The length, L_D [m], is the length of the bottom caisson or the distance from the aft end of the aftermost pontoon to the fore end of the forward pontoon, but is exclusive of non-integral end platforms or swing bridges.

1.3.1.4 Amidships is to be taken as the middle of the length L_D.

1.3.1.5 The breadth, B_D, is the moulded breadth, [m].

1.3.1.6 The depth, D_D [m], is the vertical distance from the lowest point of the bottom framing to the lower surface of the uppermost deck plating.

1.3.1.7 The top deck is the deck extending over the top of the wing walls.

1.3.1.8 The safety deck is a watertight deck arranged at such a distance below the top deck that when all tanks below the safety deck are flooded, a freeboard of at least 1 [m] is available to the top deck. Alternative arrangements to the fitting of a safety deck will be specially considered.

1.3.1.9 The rest-water is the ballast water in the tanks which the pumps cannot discharge.

1.3.1.10 Compensating ballast water is ballast water which may be used to limit the deflection of the dock by counteracting the ship-induced longitudinal bending moment. Rest-water should not be included in compensating ballast water.

1.4 Freeboard

1.4.1 The freeboard to the pontoon deck at the centerline of the dock when supporting a ship having a displacement equal to the lifting capacity (as defined in 1.3.1.1) is to be not less than 300 [mm]. When the pontoon deck at the inner side walls is lower than at the center, the freeboard to the pontoon deck at the inner side walls is to be not less than 75 [mm] and the freeboard at the centerline is to be not less than 300 [mm].

1.4.2 The above freeboard values are for level trim condition assuming that the crane(s) are positioned suitably to achieve level trim. Movement of cranes to the forward end or to the after end of the dock should not result in submergence of any part of the pontoon deck.

1.4.3 The above freeboards are considered adequate for sheltered water operation. In other areas it is recommended that they are suitably increased.

1.5 Stability

1.5.1 The dock should have a metacentric height (GM) of at least 1.0 [m] for the following conditions of submergence:

a) Full dock submergence upto the minimum freeboard level to top deck.
b) the submergence draught to the top of keel block assuming full weight of the docked ship supported on blocks.
c) The dock in final working condition with the likely most unfavourable docked ship.

1.5.2 Any additional requirements of the Statutory Authorities regarding Stability are to be satisfied by the dock.

1.5.3 For operating sites exposed to wind heeling moments, these effects should be taken into account.

In general, the angle of heel due to wind heeling moment should not result in submergence of any part of the pontoon deck.
The wind heeling moment may be calculated from the following formula:

$0.613 \times 10^{-3} \times V^2 AH$ [kN-m]

where,

A = the longitudinal projected area of the exposed surface including exposed areas of docked ship [m^2].

H = ΔH + ½ d [m]

ΔH = vertical distance from the center of A to the water line of the dock [m].

d = draught of the dock [m]

V = wind velocity [m/sec.], the wind velocity is not to be less than 25 [m/s] in general. However, the values of the wind velocity will depend on the service location and the mode of operation of the dock and may be considered more precisely in each case.

1.6 Immersion trials

1.6.1 On completion of the dock, trials are to be carried out to ascertain the following:

a) The freeboard to top deck with the dock flooded

b) The light displacement and the lifting capacity of the dock corresponding to the minimum freeboard

c) The position of center of gravity by an inclining test

d) Any permanent deflection in the initial condition. In the initial condition, all tanks for consumables are completely filled, but all other tanks are empty, only the rest water remaining in ballast tanks. The traveling cranes may be parked in positions giving equal drafts forward and aft.

e) Calibration of the deflection meters are to be carried out, simulating the most severe intended loading condition as far as practicable.

1.7 Ocean towage

1.7.1 The class of a floating dock will be assigned after it has reached its port of operation and been subjected to a satisfactory general examination.

1.7.2 Where it is intended that the dock be towed at sea from its port of construction to port of operation or from one port of operation to another, the aspects specified below will need to be investigated at an initial stage of design development:

a) The longitudinal strength is to be evaluated considering the estimated design voyage wave bending moment. Estimates of design voyage bending moment will be based on draught in towage condition, towage route and season.

   In order to minimize the design voyage wave bending moment, it is recommended that the voyage be undertaken at as close to the light draught as possible.

b) Particular attention should be given to the resistance to buckling of transversely framed bottom structure when the dock is subjected to wave induced hogging moments.

c) In addition the following will be required for issuance of a Towage Certificate:

   i) The aprons/working platforms are to be removed from the ends of a dock prior to an ocean tow.

   ii) Where the traveling crane(s) are to be mounted on the wing walls prior to towage then the proposed sea fastenings should be submitted for approval. The securing arrangements for any items carried on the pontoon deck should be to the Surveyor's satisfaction.

   iii) Emergency anchoring arrange-ments should be provided to the Surveyor's satisfaction. Considera-tion should be given to the method by which the dock could be boarded during the tow by the personnel required to release the anchors.

   iv) Other information for towage is to be submitted such as:

      - details of the tug and the towing gear;
      - details of the towing attachments, bridle recovery arrangements, secondary towing gear, etc.

Section 2

Hull Arrangement and Strength

2.1 General

2.1.1 It is recommended that the bottom, side and deck plating are longitudinally stiffened.

2.1.2 In general, the requirements and general principles given in Part 3, Chapter 2 “Materials for Construction” and Part 3, Chapter 3 “Principles of Scantlings and Structural details” are to be applied, as appropriate.

2.2 Longitudinal strength

2.2.1 General

2.2.1.1 The general requirements for longitudinal strength given in Pt.3, Ch.5 are to applied for steel floating docks along with the requirements in Sec.2.2.2 to 2.2.5 of this chapter.
The floating dock is to be considered as a Category I vessel as per Pt3 Ch.5. Operating and ballasting manual and deflection control system are to be provided in lieu of loading manual and loading instrument.

2.2.2 Still water bending moment

2.2.2.1 The SWBM is to be calculated for the condition when the ship of length L_s is supported on the keel blocks, the center of the ship's length being over the mid-length of the dock and the freeboard at the pontoon deck is at least equal to that given in 1.4.1.

2.2.2.2 Dock buoyancy distribution may be assumed rectangular over the length of the dock L_D.

2.2.2.3 The weight curve of the ship can be taken as a rectangle with a superimposed parabola of half the area of the rectangle, the length of each area being L_s.

2.2.2.4 Considering the distribution of weight and buoyancy indicated in 2.2.2.3 and 2.2.2.4 above, an approximate value of the maximum sagging BM generated during docking of the ship is given by the following expression:

$$M_s = W\left[1.25\ L_D - 1.146\ \ L_s\right] \quad [\text{kN m}]$$

W = Lifting capacity of the dock [t]

L_S = The length between perpendiculars of the shortest ship whose displacement is equal to the lifting capacity of the dock [m]; Normally L_S is not to be taken less than 0.8 L_D.

2.2.2.5 Where compensating ballast water is proposed to be used to reduce the bending moments in the normal operating conditions, lower values of still water bending moments may be approved. The operating manual should include instructions for distribution of ballast in such cases.

2.2.3 Required section modulus

2.2.3.1 The required section modulus of the dock at mid length is to be evaluated based on the still water bending moment given in 2.2.2 and a permissible stress of 140 [N/mm^2]. Reduced values of still water bending moment may be considered where compensating ballast water is used as mentioned in 2.2.2.5.

2.2.3.2 Scantlings of all related longitudinal material of the hull girder are to be continuous over a length of 0.4 L_D in the mid length region of the dock. In the region outside 0.4 L_D the scantlings may be gradually tapered to the requirement at ends.

2.2.3.3 The section modulus required as per 2.2.3.1 above is to be used while calculating factors “f_B” and “f_D” for the evaluation of permissible stresses for local structure according Part 3 of these Rules as mentioned in Sec 2.5 of this chapter.

2.2.4 Calculation of section modulus

2.2.4.1 The material to be included in the calculation of the section modulus will be, for the caisson type dock, all continuous fore and aft material.

For the pontoon type dock, all continuous fore and aft material of the wing walls structure may be included. The fore and aft material of the parts of the pontoon structure which are continuous or scarphed longitudinally for at least 2 [m] at the end of each pontoon may also be included.

2.2.4.2 The crane rail is not to be included in section modulus calculation.

2.2.5 Deflection control system

2.2.5.1 Two completely independent deflection meters are to be fitted and be capable of outputting deflections over the length of the dock L_D. One of the two deflection monitoring systems required should be of the hydraulic type. In all cases the systems should be arranged so as to measure the longitudinal deflection of a wing wall.

2.2.5.2 The readings of one of the systems installed should be displayed on an indicator board in the control room of the dock.

2.2.5.3 Consideration will be given to acceptance of only one deflection control system for docks designed to operate without using differential ballasting. Such a system could then be of optical type.

2.2.5.4 In all cases the methods of monitoring and limiting the dock deflections in service are to be submitted for approval. These methods are to include arrangements for visual and audible warning and also for ballast pumps to be stopped automatically before the maximum allowable deflection is reached.

2.2.5.5 The maximum allowable deflection is that corresponding to a bending stress of 140 [N/mm^2] when lifting a ship as detailed in 2.2.2.

2.3 Transverse strength

2.3.1 The primary transverse strength members of the dock are to be evaluated for the following load cases considering combined effect of the self weight of the dock, weight of the docked ship, external hydrostatic pressure and weight of ballast water that are acting in way of the transverse member.

a) Load case 1: Docked ship condition with the minimum freeboard at the pontoon deck.

b) Load case 2: Docked ship condition as in load case 1 with no load from the docked ship on the keel blocks at the ends of the dock. The transverse structure of the dock at the ends is to be evaluated for loads due to self-weight, buoyancy and compensating ballast water.

c) Load case .3: Transient condition with dock emerging out of water with ship fully supported on the blocks and water level up to the top of the keel blocks.

2.3.2 In the load cases mentioned in 2.3.1, the load due to docked ship at any section is to be based on the maximum value of ship weight per metre obtained from the weight distribution in 2.2.2.3, which is given by:

$$w_s = \frac{1.167 \quad W}{L_s} \quad [t/m]$$

where,

w_s = ship weight per unit length [t/m],
W = maximum lifting capacity [t],
L_s = length [m] of shortest contemplated ship associated with docking weight W

The whole of the ship weight should be assumed supported by keel blocks.

2.3.3 The wing wall reactions are to be considered acting on the transverse section as required to give equilibrium to the section. These reactions at inner and outer wing walls may be taken as equal.

2.3.4 The compressive and tensile stresses computed for the loading conditions given in 2.3.1 should not exceed 170 [N/mm^2]. The mean shear stress at any section through the web plating of the primary transverse members should not exceed 100 [N/mm^2] and the Von Mises combined stress at any point should not exceed 200 [N/mm^2].

2.3.5 For the purpose of stress evaluation the section modulus of the primary transverse strength members is to comprise the continuous transverse material over the effective width of the primary member.

2.4 Buckling

2.4.1 The structural panels, stiffeners and other members are to satisfy the requirements of resistance to buckling as given in Pt.3, Ch.3, Sec.6.

2.5 Local strength

2.5.1 Shell and tank structure

2.5.1.1 The design pressures for plating, stiffeners and girders of the shell, tank top and tank bulkheads are to be based on the following:

p = applicable design pressure

= 0.01 h [N/mm^2],

where:

a) For ballast tanks, "h" is the greatest of the following distances [m] from the load point of the structural member (see Pt.3, Ch.4, Sec.3.1 for definition of load point):

i) To a point located at two-thirds of the distance from the top of the tank to the top of the overflow. As an alternative, the maximum differential head in service may be used based on the highest levels to which water will rise on each side of the structure. Where the head is obtained using the maximum differential head in service, data on operating the dock within such limits should be included in the operating manual;

ii) 3.5 [m].

b) For all other tanks, the greatest of the following distances [m] from the load point:

i) To a point located two-thirds of the distance from the top of the tank to the top of the overflow

ii) To the maximum immersion waterline for wing wall and pontoon plating

iii) 3.5 [m]

c) For void spaces and cofferdams, the greater of the following distances [m] from the load point:

i) To the maximum immersion waterline, for wing wall and pontoon plating
ii) 3.5 [m]

2.5.1.2 The plate thickness and scantlings of structural members of bottom shell, side shell and tank bulkheads are to be not less than that calculated using the design pressure given in 2.5.1.1 in the basic formulae given in Pt.3, Ch.3, Sec.3, and Sec.4.

The permissible stresses to be used for the above calculations are to be as given in the appropriate chapters of Pt 3 (Ch7, 8 or 10).

2.5.1.3 The minimum required thickness of tank and shell plating is 7.0 [mm].

2.5.2 Cross ties

2.5.2.1 The cross ties connecting transverses in wing walls are to meet the requirements for resistance against buckling using the criteria given in Pt.3, Ch.3, Sec.6. The loads are to be based on the area supported by the cross tie and design pressures in 2.5.1.

2.5.3 Top deck

2.5.3.1 The plate thickness and scantlings of structural members of top deck are to be not less than that calculated using the basic formulae given in Pt.3, Ch.3. Sec.3 and Sec.4 and a design pressure of 0.005 [N/mm^2]. The permissible stresses are to be determined as per Pt.3, Ch.9, Sec.4 and Sec.5.

The thickness of top deck plating is to be also not less than 7.0 [mm].

2.5.4 Safety deck

2.5.4.1 The plate thickness and scantlings of structural members in the area of safety deck forming part of tanks is to be based on design pressure as given in 2.5.1 and the basic formulae in Pt.3, Ch.3, Sec.3 and Sec.4. However the minimum head of 3.5 [m] specified in 2.5.1.1 a), b), c) need not be applied to safety deck tank top. The areas of safety deck which are not forming top of tanks may be based on a design pressure of 0.005 [N/mm^2].

The permissible stresses are to be based on Pt3 Ch 9, sec 4 and sec 5.

The thickness of safety deck plating is not to be less than 7.0 [mm].

2.5.5 Keel block and supporting structure

2.5.5.1 The keel block and their supporting structure are to be designed for a uniform load equal to the maximum ship weight per unit length "w_s" given in 2.3.2. and permissible stress of 160/k [N/mm^2].

2.5.6 Cranes

2.5.6.1 Where cranes are fitted, the resulting loads on the dry-dock structure are to be indicated in the plans. The total crane weight including hook load and the arrangement of wheels and rails are to be submitted for approval of the supporting structure. Certification of cranes would be specially considered.

2.6 Ventilation and access

2.6.1 All tanks are to have vent or overflow pipes that terminate well above the water line at the maximum submergence draft of the dock. All compartments are to be provided with manholes for access and openings are to be arranged to provide adequate ventilation and access to all parts of the structure.

2.7 Tank testing

2.7.1 Ballast tanks, oil tanks, freshwater tanks and cofferdams are to be tested by a head of water to the highest point to which the liquid will rise in service. Where the scantlings of a tank boundary are based on the maximum differential head in service, care is to be taken to ensure that the test heads do not exceed the design differential head.
Leak testing may be accepted (See Pt.3, Ch.18, Sec.3) as an alternative, provided selected tanks are subject to hydraulic testing as above.

Section 3

Machinery and Electrical Installations

3.1 Machinery

3.1.1 Machinery such as boilers, pressure vessels, auxiliary engines, compressors, pumps etc., essential for the operation of the floating dock are to be constructed and installed in accordance with the relevant requirements of Part 4 of the Rules.

3.2 Piping systems

3.2.1 The piping systems are to be generally in accordance with the relevant requirements of Pt.4, Ch. 2 and Ch.3.

3.2.2 The dock is to have at least two water ballast pumps. The arrangements for de-ballasting are to be such that in case of failure to one pump an alternative pumping is available for each ballast tank.

3.2.3 Where the valves in ballast system are power operated, arrangements are to be provided for manual operation in the event of power failure. Instructions are to be provided in the operating manual of the dock that the sea inlet, discharge and distribution valves, in the ballast systems are to be immediately closed in the event of power failure during ballasting / de-ballasting.

In this case it is recommended that the ballast distribution valves are fitted with fail safe devices, automatically closing them in case of power failure.

3.3 Electrical equipment

3.3.1 Electrical installations are to be generally in accordance with the requirements of Pt.4, Ch.8 of the Rules.

Section 4

Fire Safety

4.1 General

4.1.1 This section gives the minimum requirements for fire protection, detection and extinction applicable to the floating dock and do not cover equipment fitted for fighting fires that may occur on the docked ship.

However, provision is to be made for connecting the fire fighting system of the dock to the docked vessel fire fighting system as indicated in 4.4.1. Attention should also be given to any relevant statutory requirements of the National Authority of the country in which the dock is to operate.

4.1.2 For definitions and details not covered in this section, reference may be made to Part 6 of the Rules.

4.2 Fire protection

4.2.1 Boundaries of machinery spaces and interior stairways below top deck are to be of steel or equivalent material.

4.2.2 Deckhouses are to be constructed of steel or equivalent material. All internal bulkheads, ceilings and linings are to be of non-combustible materials. Corridor bulkheads are to be constructed of steel or to “B” class standards of SOLAS. Bulkheads of galley, paint stores, storage spaces for flammable materials and other areas of high fire risk are to be of steel or equivalent material.

4.2.3 Exposed surfaces in corridors and stairway enclosures and surfaces in concealed and inaccessible spaces in accommodation, service spaces and control stations are to have low flame spread characteristics.

4.2.4 Paints, varnishes and other finishes used on exposed interior surfaces are not to be capable of producing excessive quantities of smoke and toxic products. Primary deck coverings within accommodation, service spaces and control stations are to be of a type which will not give rise to smoke or toxic or explosive hazards at elevated temperatures.

4.3 Fire detection systems

4.3.1 Where machinery spaces containing essential machinery of 736 kW and above are not continuously manned and a remote centralized control system is installed for the operation of machinery, a fire detection and alarm system is to be provided in those spaces.

4.3.2 There are to be not less than two sources of power supply for the electrical equipment used in the operation of the fire detection and fire alarm system, one of which is to be an emergency source.

4.3.3 The location and spacing of detectors are to be suitable for optimum performance. The activation of any detector is to initiate a visual and audible signal at the continuously manned central control station.

4.4 Fire pumps, hydrants and hoses

4.4.1 The fire pumps, associated piping and fire main are to be so designed that a minimum pressure can be maintained at all hydrants of the dry dock and the largest vessel to be docked, sufficient to produce jet throw of at least 12 [m] through any adjacent hydrants with nozzles of size as required by 4.4.4. A fire main is to be provided on each dock wing. Two separate means of water supply are to be provided for the fire main.

4.4.2 If fire in one compartment could put all the fire pumps out of action, an alternative means through an independently driven emergency fire pump is to be provided. The emergency fire pump is to be located in a space, which will be accessible in case of fire in the space containing the main fire pumps. If shore side supply for fire fighting is readily available, consideration may be given for dispensing with the requirement of emergency fire pump.

4.4.3 The number and positions of the hydrants are to be such that at least two jets of water not emanating from the same hydrant, one of which is to be from a single length of hose, may reach any part of the dock except the water ballast tanks under any operating conditions.

Two hydrants are to be provided in spaces containing machinery with a total power of 736 kW and over. One hydrant may be accepted in other machinery spaces. Where, fire fighting from within a small compartment is impracticable due to limitations in space, the hydrants may be situated outside and adjacent to the compartment entrance.

4.4.4 For accommodation and service spaces, a nozzle size of 12 [mm] may be adequate. For machinery space and exterior locations, nozzle sizes of 12 [mm], 16[mm] or 19[mm] may be used so as to obtain maximum discharge possible from the fire pumps.

4.4.5 It is recommended that an international shore connection is provided according to the specification given in Pt.6, Ch.8, Sec 2.

4.5 Portable fire extinguishers

4.5.1 Accommodation, service spaces and control stations are to be provided with portable fire extinguishers so placed that at least one extinguisher will be readily accessible from any part of the spaces.

4.5.2 For galleys and spaces containing domestic boilers, one portable fire extinguisher suitable for dealing with oil fires or fires in electric cooking equipment, as appropriate, is to be provided.

4.5.3 In machinery spaces portable fire extinguishers appropriate to the type of machinery are to be provided.

4.6 Fixed gas fire extinguishing systems

4.6.1 Where provision is made for injection of gas into machinery spaces for fire extinguishing purposes, the necessary pipes for conveying the gas are to be provided with control valves so marked as to indicate clearly the spaces to which the pipes are led. The valves are to be so positioned that they are readily accessible and not likely to be cut off by a fire in the protected space. Suitable provision is to be made to prevent inadvertent release of the medium into that space.

End of Chapter

Rules and Regulations for the Construction and Classification of Steel Ships

Part 5

Special Ship Types

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IRCLASS

Indian Register of Shipping

Indian Register of Shipping

Part 5 : Special Ship Types

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Chapter 21

Ice Class Requirements

Contents

Section

Section 1

General

1.1 Application

1.1.1 The Rules in this Chapter apply to vessels occasionally or primarily intended for navigation in waters with ice conditions. The requirements are to be regarded as supplementary to those given for the assignment of main class.

1.2 Class notations

1.2.1 Vessels complying with relevant additional requirements of this Chapter will be eligible to be assigned one of the following class notations:

a) **HAT(B)** : This strengthening is for first year ice conditions in Northern Baltic in winter or areas of similar ice with condition equivalent to unbroken level ice with a maximum thickness of 1.0 [m].

b) **HT(B)** : This strengthening is for first year ice conditions in Northern Baltic in winter or areas of similar ice with condition equivalent to unbroken level ice with a maximum thickness of 0.8 [m].

c) **HM(B)** : This strengthening is for first year ice conditions in Northern Baltic in winter or areas of similar ice with condition equivalent to unbroken level ice with a maximum thickness of 0.6 [m].

d) **Ha(B)** : This strengthening is for first year ice conditions in Northern Baltic in winter or areas of similar ice with condition equivalent to unbroken level ice with a maximum thickness of 0.4 [m].

e) **Ha** : This strengthening is for light first year ice conditions in areas other than Northern Baltic. The standard of strengthening is equivalent to that for **Ha(B)** but only the requirements for strengthening the forward region, the rudder and steering arrangements are applicable.

1.3 Symbols

L, B, D, T, C_b as defined in Pt.3, Ch.1.

Δ = moulded displacement, [t] at summer load waterline.

Δ_f = displacement, [t] in fresh water i.e. considering a density of 1.0 [t/m^3], at maximum ice class draught given in 2.2.1.

P = maximum continuous output of propulsion machinery [kW].

s = stiffener spacing, [mm] measured along the plating between ordinary and/or intermediate stiffeners.

l = stiffener span, [m] measured along the top flange of the member.

S = girder span, [m].

σ_y = minimum yield stress of material, [N/mm^2].

g_o = standard acceleration due to gravity.

= 9.81 [m/s^2].

Section 2

Hull Strengthening for First Year Ice Conditions

2.1 General

2.1.1 The requirements of this Section apply to vessels for service in the Northern Baltic in winter or areas with similar first year ice conditions.

2.1.2 Vessels built in compliance with the following requirements may be given one of the class notations **HAT(B), HT(B), HM(B)** or **Ha(B)** whichever is relevant. For class notation **Ha** the requirements of **Ha(B)** are to be applied as per 1.2.1(c) above.

2.1.3 The formulae given for plating, stiffeners and girders are based on the distribution of ice loads from plating to stiffeners and girders as well as redistribution of loads on stiffeners and girders.

2.1.4 If scantlings derived from these regulations are less than those required for an unstrengthened ship, the latter are to be used.

2.1.5 Assistance from icebreakers is normally assumed when navigating in ice bound waters.

2.2 Definitions

2.2.1 The maximum ice class draught amidships is the draught on the Fresh Water Load Line in Summer. If the ship has a timber load line, the Fresh Water Timber Load Line in Summer is to be used.

2.2.2 The maximum and minimum ice class draughts fore and aft are to be determined and stated in the classification certificate. The line defined by the maximum draughts fore, amidship and aft (may be a broken line) will henceforth be referred to as LWL. The line defined by the minimum draughts fore and aft will be referred to as BWL.

The draught and trim, limited by the LWL, must not be exceeded when the ship is navigating in ice. The salinity of the sea water along the intended route is to be taken into account when loading the ship. Any ballast tank, situated above the BWL and needed to load down the ship to this water line, is to be equipped with devices to prevent the water from freezing. In determining the BWL, regard is to be paid to the need for ensuring a reasonable degree of ice going capability in ballast. The propeller is to be fully submerged, if possible entirely below the ice. The minimum forward draught is to be at least:

$(2 + 0.00025\ \Delta_f)\ h_o$ [m],

but need not exceed 4 h_o

where,

h_o = ice thickness as per 2.3.1.

2.2.3 The ice belt is divided into regions as follows : (See Fig.2.2.3).

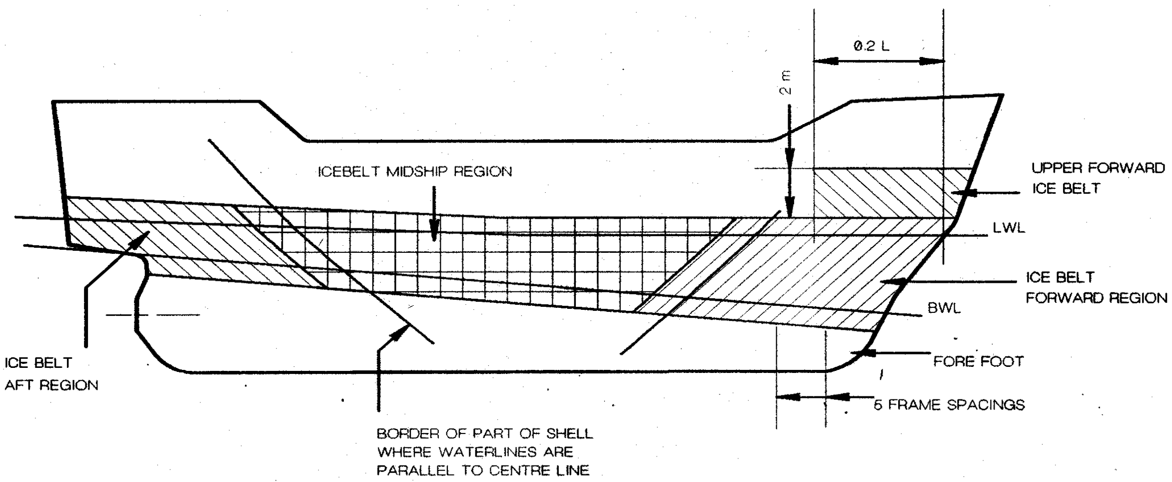


Fig.2.2.3 : Ice belt regions

Forward region : From the stem to a line parallel to and 0.04L aft of the forward borderline of the part of the hull where the waterlines run parallel to the centreline. For ice classes **HAT(B)** and **HT(B)** the overlap of the borderline need not exceed 6 [m], for ice classes **HM(B)** and **Ha(B)** this overlap need not exceed 5 [m].

Midship region : From the aft boundary of the Forward region to a line parallel to and 0.04 L aft of the aft borderline of the part of the hull where the waterlines run parallel to the centreline. For ice classes **HAT(B)** and **HT(B)** the overlap of the borderline need not exceed 6 [m], for ice classes **HM(B)** and **Ha(B)** this overlap need not exceed 5 [m].

Aft region : From the aft boundary of the Midship region to the stern.

2.2.4 LWL and BWL are to be indicated on the shell expansion plan together with the lines separating the forward, amidships and aft regions of the ice belt. The displacement Δ_f, and the output of propulsion machinery P, are to be stated on the shell expansion and/or the framing plan.

2.3 Design loads

2.3.1 An ice strengthened ship is assumed to operate in open sea conditions corresponding to a level ice thickness not exceeding h_o. The design height (h) of the area actually under ice pressure at any particular point of time is, however, assumed to be only a fraction of the ice thickness. The values of h_o and h are given in Table 2.3.1.

Table 2.3.1 : Ice thicknesses

Ice Class	h_o [m]	h [m]
HAT(B)	1.0	0.35
HT(B)	0.8	0.30
HM(B)	0.6	0.25
Ha(B)	0.4	0.22

2.3.2 The design ice pressure is determined by the formula:

$p = 5.6\, c_d\, c_1\, c_a$ [N/mm^2]

c_d = a factor which takes account of the influence of the size and engine output of the ship.

$$c_d = \frac{aK + b}{1000}$$

$$K = \frac{\sqrt{\Delta_f P}}{1000}$$

a and b are given in Table 2.3.2.

Table 2.3.2

	Region			
	Forward		Midship and Aft	
	K ≤ 12	K > 12	K ≤ 12	K > 12
a	30	6	8	2
b	230	518	214	286

Δ_f = displacement [t] as defined in 2.2.2.

P = machinery output [kW].

c_1 = a factor which takes account of the probability that the design ice pressure occurs in a certain region of the hull for the ice class in question.

The value of c_1 is given in the following table:

Ice class	Region		
	Forward	Midship	Aft
HAT(B)	1.0	1.0	0.75
HT(B)	1.0	0.85	0.65
HM(B)	1.0	0.70	0.45
Ha(B)	1.0	0.50	0.25

c_a = a factor which takes account of the probability that the full length of the area under consideration will be under pressure at the same time.

$$C_a = \frac{47 - 5\, l_a}{44}$$

however, not to be taken greater than 1.0 or less than 0.5

l_a is to be taken as follows:

Structure	Type of framing	l_a [m]
Shell and frames	Transverse	Frame spacing
	Longitudinal	Span of frame
Ice stringer		Span of stringer
Web frame		2 x spacing of web frames

2.4 Shell plating

2.4.1 The vertical extension of the ice belt is not to be less than the following:

Ice class	Above LWL [m]	Below BWL [m]
HAT(B)	0.6	0.75
HT(B)	0.5	0.6
HM(B)	0.4	0.5
Ha(B)	0.4	0.5

2.4.2 In addition, the following areas are to be strengthened:

Fore foot: For ice class **HAT(B)**, the shell plating below the ice belt from the stem to a position five main frame spaces abaft the point where the bow profile departs from the keel line is to have at least the thickness required in the ice belt in the midship region, calculated for the actual frame spacing.

Upper forward ice belt: For ice classes **HAT(B)** and **HT(B)** on ships with an open water service speed equal to or exceeding 18 knots, the shell plate from the upper limit of the ice belt to 2 [m] above it and from the stem to a position at least 0.2L abaft the forward perpendicular, is to have at least the thickness required in the ice belt in the midship region, calculated for the actual frame spacing.

2.4.3 Side scuttles are not to be situated in the ice belt. If the weather deck in any part of the ship is situated below the upper limit of the ice belt (e.g. in way of the well of a raised quarter decker), the bulwark is to be given at least the same strength as is required for the shell in the ice belt. Special consideration has to be given to the design of the freeing ports.

2.4.4 For transverse framing, the thickness of the shell plating is to be determined by the formula:

$$t = 0.578s\sqrt{\frac{x_1 p}{\sigma_y}} + t_c \text{ [mm]}$$

For longitudinal framing the thickness of the shell plating is to be determined by the formula:

$$t = 0.578s\sqrt{\frac{p}{x_2\,\sigma_y}} + t_c \text{ [mm]}$$

p = as given in 2.3.2.

$$x_1 = 1.3 - \frac{4.2}{(h_1/s + 1.8)^2};$$

but not to be taken greater than 1.

$$x_2 = 0.6 + \frac{0.4}{h_1/s}; \text{ for } (h_1/s) \le 1$$

= 1.4 - 0.4 (h_1/s); for 1 ≤ (h_1/s) < 1.8

= 0.35 + 0.183 (h_1/s); for 1.8 ≤ (h_1/s) < 3

= 0.9 for (h_1/s) ≥ 3

h_1 = 1000 h

h = as given in 2.3.1;

t_c = addition for abrasion and corrosion [mm]; normally 2 [mm]. Where special surface coatings, with proven ability to withstand the abrasion of ice is applied and maintained, lower values of t_c may be considered.

2.5 Frames

2.5.1 The vertical extension of the ice strengthening of the framing is to be at least as per Table 2.5.1.

Where an upper forward ice belt is required, the ice strengthening of the framing within that area is to be extended above the LWL by 1 [m] in addition to the table value for **HAT(B)** and **HT(B).**

Table 2.5.1			
Ice Class	**Region**	**Above LWL [m]**	**Below BWL [m]**
HAT(B)	Forward: from stem to 0.3L abaft it	1.2	To double bottom or below top of floors
	Forward: abaft 0.3L from stem	1.2	1.6
	Midship	1.2	1.6
	Aft	1.2	1.2
HT(B) HM(B) Ha(B)	Forward: from stem to 0.3L abaft it	1.0	1.6
	Forward: abaft 0.3L from stem	1.0	1.3
	Midship	1.0	1.3
	Aft	1.0	1.0

2.5.2 Where the ice strengthening would go beyond a deck or a tanktop by not more than 250 [mm], it can be terminated at that deck or tanktop.

2.5.3 The section modulus of main or intermediate transverse frame is to be calculated by the formula:

$$Z = \frac{p\,s\,h\,l}{m_t\ \sigma_F}\ 10^3\ \ [cm^3]$$

p = ice pressure [N/mm^2] , as given in 2.3.2

h = height of load area [m], as given in 2.3.1

$$m_t = \frac{7m_o}{7-5h/l}$$

m_o = values are given in the Table 2.5.3.

The boundary conditions are those for the intermediate frames. Possible different conditions for main frames are assumed to be taken care of by interaction between the frames and this is included in the m_o values. Load is applied at mid span.

If the ice belt covers less than half the span of a transverse frame (b < 0.5 *l*), the following modified formula is to be used for the section modulus:

$$Z = \frac{p\,s\,h\,b\,(l-b)^2}{\sigma_y\ l^2}\ 10^3\ \ [cm^3]$$

b = distance [m], between upper or lower boundary of the ice belt and the nearest deck or stringer within the ice belt.

When b < 0.1 *l*, ordinary main class rule scantlings may be used.

2.5.4 Upper end of transverse framing

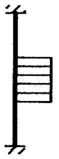
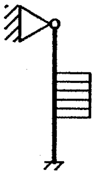
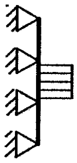
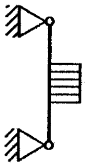
i) The upper end of the strengthened part of main frame and of an intermediate ice frame is to be attached to a deck or an ice stringer (See 2.6).

ii) Where an intermediate frame terminates above a deck or an ice stringer which is situated at or above the upper limit of the ice belt, the part above the deck or stringer may have the scantlings required for an unstrengthened ship and the upper end be connected to the adjacent main frames by a horizontal member of the same scantlings as the main frame. Such an intermediate frame can also be extended to the deck above and if this is situated more than 1.8 [m] above the ice belt, the intermediate frame need not be attached to that deck, except in the forward region.

2.5.5 Lower end of transverse framing

i) The lower end of the strengthened part of a main frame and of an intermediate ice frame is to be attached to a deck, tank top or ice stringer (See 2.6).

ii) Where an intermediate frame terminates below a deck, tanktop or ice stringer which is situated at or below the lower limit of the ice belt, the lower end is to be connected to the adjacent main frames by a horizontal member of the same scantlings as the main frame.

Table 2.5.3		
Boundary condition	**M_o**	**Example**
	7	Frames in a bulk carrier with top wing tanks
	6	Frames extending from the tank top to a single deck
	5.7	Continuous frames between several decks or stringers
	5	Frames extending between two decks only

2.5.6 The section modulus of longitudinals is to be calculated by the formula:

$$Z = \frac{x_3\ x_4\ p\, h\, l^2}{m_l\ \sigma_y}\ 10^6\ [cm^3]$$

The shear area of longitudinals is to be:

$$A = \frac{8.7\ x_3\ p\, h\, l}{\sigma_y}\ 10^3\ [cm^2]$$

These formulae assume that the longitudinal frame is attached to supporting structure by brackets.

x_3 = factor which takes account of the load distribution to adjacent frames:

x_3 = (1 - 200 h/s)

x_4 = factor which takes account of the concentration of load to the point of support:

x_4 = 0.6

p = ice pressure [N/mm^2], as given in 2.3.2

h = height of load area [m], as given in 2.3.1

m_l = boundary condition factor;

= 13.3 for a continuous beam. Where the boundary conditions deviate significantly from a continuous beam, a smaller factor may be required.

= 12 for longitudinals, considering load variations between adjacent spans.

2.5.7 Within the ice strengthened area, all frames are to be effectively attached to all supporting structures by brackets. Frames crossing supporting structures such as web frames or stringers are to be connected to these structures on both sides (by collar plates or lugs in way of cutouts).

2.5.8 For ice class **HAT(B),** for ice class **HT(B)** in the forward and midship regions and for ice classes **HM(B)** and **Ha(B)** in the forward region the following is to apply in the ice strengthened area:

i) Frames which are not perpendicular to the shell, are to be supported against tripping by brackets, intercostals, stringers or similar at a distance preferably not exceeding 1.3 [m].

ii) Frames and girder webs are to be attached to the shell by double continuous welds. No scalloping is allowed (except when crossing shell plate butts).

iii) The web thickness of the frames is to be at least one half of the thickness of the shell plating but not less than 9 [mm]. Where there is a deck, tanktop or bulkhead in lieu of a frame, the plate thickness of this is to be as above, to a depth corresponding to the height of adjacent frames.

2.6 Ice stringers

2.6.1 The section modulus of a stringer situated within the ice belt is to be calculated by the formula:

$$Z = \frac{0.9\,p\,h\,l^2}{m_l\,\sigma_y}\,10^6\ [cm^3]$$

The shear area is not to be less than:

$$A = \frac{7.8\,p\,h\,l}{\sigma_y}\,10^3\ [cm^2]$$

p = ice pressure [N/mm^2], as given in 2.3.2.

h = height of load area [m] as given in 2.3.1.

The product "p h" is not to be taken as less than 0.3

l = span of stringer [m]

m_l = boundary condition factor as given in 2.5.6.

2.6.2 The section modulus of a stringer, situated outside the ice belt but supporting ice strengthened frames, is to be calculated by the formula:

$$Z = \frac{0.95\,p\,h\,l^2}{m_l\,\sigma_y}\left(1 - \frac{h_s}{l_s}\right)10^6\ [cm^3]$$

The shear area is not to be less than:

$$A = \frac{8.2\,p\,h\,l}{\sigma_y}\left(1 - \frac{h_s}{l_s}\right)10^3\ [cm^2]$$

p, h, l, m_l as in 2.6.1

The product "p h" is not to be taken as less than 0.3.

l_s = distance to the adjacent ice stringer [m]

h_s = distance to the ice belt [m].

2.6.3 Narrow deck strips abreast of hatches and serving as ice stringers are to comply with the section modulus and shear area requirements in 2.6.1 and 2.6.2 respectively. In the case of very long hatches, the lower limit of the product "p h" may be reduced to 0.2.

2.6.4 Regard is to be paid to the deflection of the ship's sides due to ice pressure in way of very long hatch openings, when designing weather deck hatchcovers and their fittings.

2.7 Web frames

2.7.1 For transverse web frames supporting longitudinals or ice stringers, the load transferred to the web frame is given by:

$$F = x_5\ p\ h\ S\ \ 10^3\ [kN]$$

x_5 = 1.0 for longitudinals

= 0.9 for stringers

p = ice pressure [N/mm^2], obtained as per 2.3.2, considering the value of c_a which is to be calculated taking l_a = 2S.

h = height [m] of load area, as given in 2.3.1.

The product "p h" is not to be taken less than 0.3.

S = web frame spacing, [m].

In case the supported stringer is outside the ice belt, the load F may be multiplied by the factor $(1 - h_s / l_s)$.

For h_s, l_s See 2.6.2.

2.7.2 For a web frame simply supported at the upper end and fixed at the lower end (See Fig.2.7.2), the section modulus requirement is given by:

$$Z = \frac{k_1 F l}{\sigma_y} \sqrt{\frac{1}{1.3 - [\gamma (A/A_a)]^2}}\ 10^3\ [cm^3]$$

where,

$$k_1 = \frac{1}{2}\left(\frac{l_f}{l}\right)^3 - \frac{3}{2}\left(\frac{l_f}{l}\right)^2 + \frac{l_f}{l}$$

l = span [m] of web frame

γ = as given in Table 2.7.3.

l_f = distance [m], from the lower support of the web frame to the stringer or longitudinal in question.

A = required shear area [cm^2], from 2.7.3 obtained using the first formula given for factor k_2.

A_a = actual cross sectional area of web plate, [cm^2].

F = load force as given in 2.7.1.

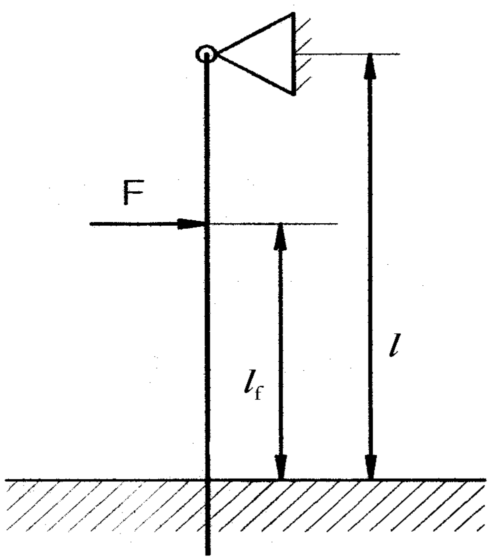


Fig.2.7.2 : Web frame

2.7.3 With boundary conditions as given in 2.7.2, the shear area of a web frame is given by:

$$A = \frac{17.3 \alpha k_2 F}{\sigma_y}\ [cm^2]$$

where,

$$k_2 = 1 + \frac{1}{2}\left(\frac{l_f}{l}\right)^3 - \frac{3}{2}\left(\frac{l_f}{l}\right)^2 \text{ or}$$

$$= \frac{3}{2}\left(\frac{l_f}{l}\right)^2 - \frac{1}{2}\left(\frac{l_f}{l}\right)^3$$

whichever is the greater.

l_f = as given in 2.7.2. When calculating the shear area at the lower end, the smallest possible l_f within the ice belt is to be used. For the upper end, the biggest l_f within the ice belt is to be used.

F = load force as given in 2.7.1.

l = as given in 2.7.2.

α = factor given in Table 2.7.3.

A_f = cross sectional area of free flange, [cm^2].

A_w = cross sectional area of web plate, [cm^2].

Table 2.7.3

$\frac{A_f}{A_w}$	α	γ
0.0	1.41	0
0.2	1.23	0.37
0.4	1.16	0.56
0.6	1.11	0.67
0.8	1.09	0.75
1.0	1.07	0.80
1.2	1.06	0.83
1.4	1.05	0.85
1.6	1.05	0.87
1.8	1.04	0.88
2.0	1.04	0.89

2.7.4 For other web frame configuration and boundary conditions than given in 2.7.2, a direct stress calculation is to be performed.

The concentrated load on the web frame is given in 2.7.1. The point of application, in each case is to be chosen in relation to the arrangement of stringers and longitudinal frames, so as to obtain the maximum shear and bending moments.

The permissible stresses are as follows:

Shear stress: $\tau = \sigma_y/\sqrt{3}$

Bending stress: $\sigma_b = \sigma_y$

$$\text{Equivalent stress}: \sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = 1.15\sigma_y$$

2.8 Special arrangements and strengthening forward

2.8.1 The stem may be made of rolled, cast or forged steel or of shaped steel plates. A sharp edged stem (see Fig.2.8.1) improves the manoeuvrability of the ship in ice and is recommended particularly for smaller ships with length below 150 [m].

The value of 't' for welded stem may be determined as follows:

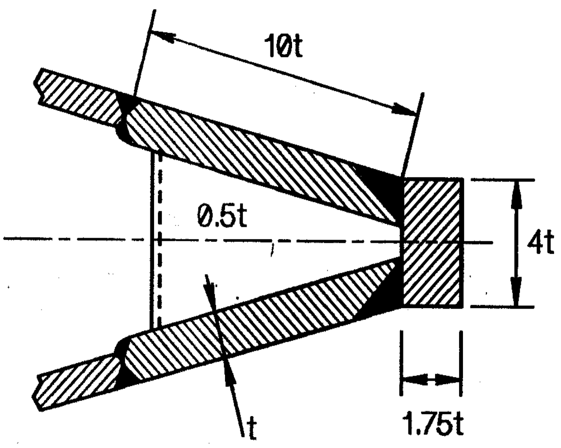


Fig. 2.8.1 : A sharp edged stem

$t = 31\ C_1 \sqrt{C_2}$ [mm]

where,

$C_1 = 0.653 + 3.217 \sqrt{\Delta_f P} \times 10^{-5}$

$C_2 = 0.14 + 2.46\ h$

h as defined in 2.3.1.

2.8.2 The plate thickness of a shaped plate stem and in the case of a blunt bow, any part of the shell which forms an angle of 30° or more to the centre line in a horizontal plane, is to be calculated according to the formulae in 2.4.4 assuming that:

s = spacing of elements supporting the plate [mm]

l_a = spacing of vertical supporting elements [m].

p = calculated from 2.3.2 to be multiplied by factor 1.33.

2.8.3 The stem and the part of a blunt bow defined above are to be supported by floors or brackets spaced not more than 0.6 [m] apart and having a thickness not less than half the plate thickness. The reinforcement of the stem is to extend from the keel to a point 0.75 [m] above LWL or, in case an upper foreward ice belt is required, to the upper limit of this.

2.8.4 A mooring pipe with an opening not less than 250 x 300 [mm], a length of at least 150 [mm] and an inner surface radius of at least 100 [mm] is to be fitted in the bow bulwark at the centre line.

2.8.5 A bitt or other means for securing a towline, dimensioned to withstand the breaking force of the towline of the ship is to be fitted.

2.8.6 On ships with a displacement not exceeding 30,000 tons, the part of the bow which extends to a height of at least 5 [m] above the LWL and at least 3 [m] aft of the stem, is to be strengthened to take the stresses caused by fork towing. For this purpose, intermediate frames supported by stringers or decks are to be fitted.

2.8.7 The connection of bilge keels to the hull is to be so designed that the risk of damage to the hull, in case the bilge keel is ripped off, is minimized.

2.8.8 To limit damage when a bilge keel is partly ripped off, it is recommended that bilge keels be cut up into several shorter independent lengths.

2.9 Special arrangement and strengthening aft

2.9.1 An extremely narrow clearance between the propeller blade tip and the stern frame is to be avoided, as a small clearance would cause very high loads on the blade tip.

2.9.2 On twin and triple screw ships, the ice strengthening of the shell and framing is to be extended to the double bottom for 1.5 [m] forward and aft of the side propellers.

2.9.3 Shafting and stern tubes of side propellers are normally to be enclosed within plated bossings. If detached struts are used, their design, strength and attachment to the hull are to be duly considered.

2.9.4 A wide transom stern extending below the LWL will seriously impede the capability of the ship to run astern in ice, which is most essential. Therefore, a transom stern is not to be extended below the LWL if this can be avoided. If unavoidable, the part of the transom below the LWL is to be kept as narrow as possible. The part of a transom stern situated within the ice belt is to be strengthened as for the midship region.

2.10 Rudder and steering arrangements

2.10.1 The scantlings of rudder, rudder post, rudder stock, pintles, steering gear etc. as well as the capacity of the steering gear are to be as per Pt.3, Ch.14. The maximum service speed of the ship in ahead condition, however, is not to be taken less than that stated below:

HAT(B) 20 knots

HT(B) 18 knots

HM(B) 16 knots

Ha(B) 14 knots

In the astern condition, half the speed value is to be used.

The factors K2 and K3 are to be taken as 1.0.

2.10.2 For the ice classes **HAT(B)** and **HT(B),** the rudder stock and the upper edge of the rudder is to be protected against ice pressure by an ice knife or equivalent means.

2.10.3 For ice classes **HAT(B)** and **HT(B),** due regard is to be paid to the excessive loads caused by the rudder being forced out of the mid position when backing into an ice ridge.

2.10.4 The components of the steering gear are to be dimensioned to withstand the yield torque of the rudder stock. Where possible, rudder stoppers working on the blade or rudder head are to be fitted.

2.10.5 Parts of rudder within the ice belt are to have local thickness at least equivalent to the side shell in the afterbody.

Section 3

Machinery

3.1 Required engine output

3.1.1 Definitions (See Fig.3.1.1)

L_{BP} = length of ship between the perpendiculars [m]

L_{BOW} = length of the bow [m]

L_{PAR} = length of the parallel midship body [m]

B_{max} = maximum breadth of the ship at LWL [m]

T_{ice} = actual ice class draughts of the ship [m] according to 3.1.2.2.

A_{wf} = area of the waterplane of the bow [m^2]

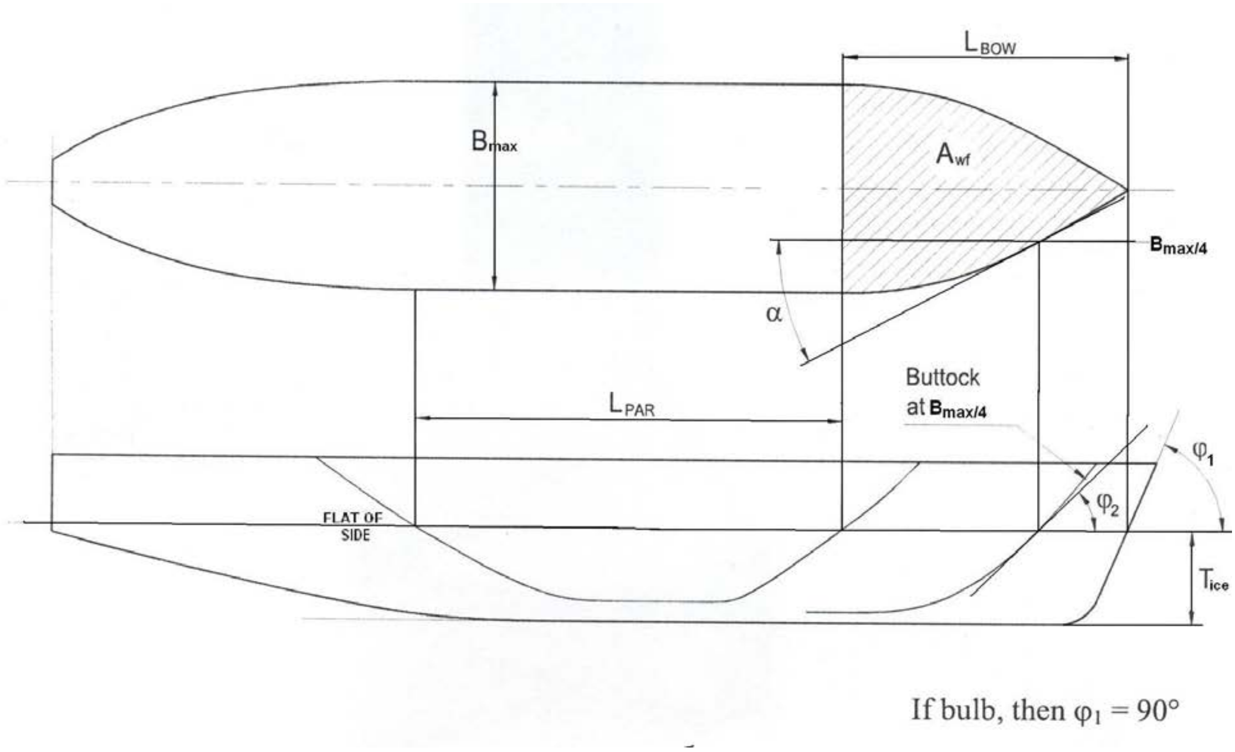


Fig.3.1.1

α = the angle of the waterline at $B_{max}/4$ [degrees]

φ_1 = the rake of the stem at the centerline [degrees]

= 90° for ship with a bulbous bow

φ_2 = the rake of the bow at $B_{max}/4$ from centerline [degrees]

D_p = diameter of the propeller [m]

H_M = thickness of the brash ice in mid channel [m]

H_F = thickness of the brash ice layer displaced by the bow [m]

H_M = thickness of the brash ice in mid channel [m]

H_F = thickness of the brash ice layer displaced by the bow [m]

3.1.2 The engine output 'P' is not to be less than the requirements given in 3.1.2.1 for ice class notation Ha and 3.1.2.2 for ice class notations Ha(B), HM(B), HT(B) and HAT(B).

3.1.2.1 For Ice Class Ha

P = 0.72 L B [kW].

3.1.2.2 For ice class notations HAT(B), HT(B), HM(B) and Ha(B). The engine output 'P' is to be not less than the greater of the values calculated for:

a) Maximum draught amidships ("LWL"), and

b) Minimum draught ("BWL")

See 2.2.2 for definitions of "LWL" and "BWL".

The ship's parameters in the calculations are to be determined at the appropriate draught excepting L_{BP} and B_{max}, which are to be determined at LWL.

$$P = K_e \frac{(R_{CH}/1000)^{\frac{3}{2}}}{D_P} \text{ [kW]};$$

where,

K_e is to be taken as follows:

Propeller type or machinery	CP or electric or hydraulic propulsion machinery	FP propeller
1 propeller	2.03	2.26
2 propellers	1.44	1.60
3 propellers	1.18	1.31

These K_e values apply for conventional propulsion systems. For advanced propulsion systems, other methods may be used for determining the required power. (See 3.1.4).

R_{CH} is the resistance [N] of the ship n a channel with brash ice and a consolidated layer, as applicable, given by:

$$R_{CH} = \Big\{ C_1 + C_2 + C_3 C_\mu (H_F + H_M)^2 (B_{max} + C_\psi H_F) + C_4 L_{PAR} H_F^2 + C_5 \left(\frac{L_{BP} T_{ice}}{B_{max}^2} \right)^3 \frac{A_{WF}}{L_{BP}} \Big\}$$

$\left(\frac{L_{BP} T_{ice}}{B_{max}^2} \right)^3$ is not to be taken as less than 5 and not to be taken as more than 20.

Coefficients C_1 and C_2, which take into account a consolidated upper layer of the brash ice are to be taken as follows:

For ice class notations HT(B), HM(B) and Ha(B): $C_1 = 0$; . $C_2 = 0$

For ice class HAT(B):

$$C_1 = f_1 \frac{B_{max} L_{PAR}}{2 \frac{T_{ice}}{B_{max}} + 1} + (1 + 0.021 \varphi_1)$$

$$(f_2 B_{max} + f_3 L_{BOW} + f_4 B_{max} L_{BOW})$$

and

$$C_2 = (1 + 0.063 \varphi_1)(g_1 + g_2 B_{max}) + g_3 \left(1 + 1.2 \frac{T_{ice}}{B_{max}} \right) \frac{B_{max}^2}{\sqrt{L_{BP}}}$$

where,

f_1 = 23 [N/m^2]

f_2 = 45.8 [N/m]

f_3 = 14.7 [N/m]

f_4 = 29 [N/m^2]

g_1 = 1530 N

g_2 = 170 [N/m]

g_3 = 400 [N/m$^{1.5}$]

$C\mu = 0.15 \cos \varphi_2 + \sin \psi \sin \alpha$; $C\mu$ is not to be taken less than 0.45

$C\psi = 0$ if $\psi \leq 45°$

$= (0.04\psi - 2.115)$ if $\psi > 45°$

where $\psi = \arctan \left(\frac{\tan \varphi_2}{\sin \alpha} \right)$

c3 = 845 kg/(m^{2}s^2)

c4 = 42 kg/(m^{2}s^2)

c5 = 825 kg/s^2

3.1.3 The range of validity of the formulae for powering requirements in 3.1.2.2 is given in Table 3.1.3.

Table 3.1.3 : Range of validity of parameters

Parameter		Minimum	Maximum
α	[degrees]	15	55
φ_1	[degrees]	25	90
φ_2	[degrees]	10	90
L_{BP}	[m]	65.0	250.0
B_{max}	[m]	11.0	40.0
T_{ice}	[m]	4.0	15.0
L_{BOW}/L_{BP}		0.15	0.40
L_{PAR}/L_{BP}		0.25	0.75
D_p/T_{ice}		0.45	0.75
$A_{wf}/(L_{BP}*B_{max})$		0.09	0.27

3.1.4 Other methods of determining K_e or R_{CH}

For an individual ship, in lieu of the K_e or R_{CH} values defined in 3.1.2 and 3.1.3, the use of K_e or R_{CH} values based on more exact calculations or values based on model tests may be approved. For this purpose a minimum speed of 5 knots and the following brash ice channels according to the desired class notation are to be assumed:

HAT(B) H_M= 1.0 m and a 0.1 m thick consolidated layer of ice

HT(B) H_M = 1.0 m

HM(B) H_M = 0.8 m

Ha(B) H_M = 0.6 m

Such approval will be subject to satisfactory performance of the ship in service.

3.1.5 All components of the main propulsion system are to be of steel or other approved ductile material.

3.1.6 For tail shafts in ships intended for the notation 'Ice Class **HAT(B)** or **HT(B)** and where the connection between the propeller and the tail shaft is by means of a key, Charpy impact tests are to be made in accordance with the requirements of Pt.2.

3.1.7 Propellers and propeller blades are to be of cast steel or copper alloys.

3.1.8 For steel propellers, the elongation of the material used is to be not less than 19 per cent for a test piece length of 5d. Charpy impact tests are to be carried out in accordance with the requirements of Pt.2.

3.2 Ice classes HAT(B), HT(B), HM(B) and Ha(B)

3.2.1 Where the notation, **HAT(B), HT(B), HM(B)** or **Ha(B)** is desired, the requirements of this Section, in addition to those for open water service, are to be complied with, so far as these are applicable.

3.2.2 Determination of ice torque

Dimensions of propellers, shafting and gearing are determined by formulae taking into account the impact when a propeller blade hits ice. The ensuing load is hereinafter defined by ice torque, M.

$M = mD^2$ [kN-m]

where,

m = 21.10 for Ice Class **HAT(B)**
= 15.69 for Ice Class **HT(B)**
= 13.04 for Ice Class **HM(B)**
= 11.96 for Ice Class **Ha(B)**

D = diameter of propeller [m]

If the propeller is not fully submerged when the ship is in ballast condition, the ice torque for Ice Class **HT(B)** is to be used for Ice Classes **HM(B)** and **Ha(B).**

3.2.3 Propeller blade sections

The width, L_p, and thickness, T_p, of propeller blade sections are to be determined so that:

a) at the radius 0.25 (D_p/2), for solid propellers

$$L_p T_p^{\,2} \geq \frac{26478000}{\sigma_u (0.65 + 0.7P_r/D_p)} \left(27.2 \frac{P_s}{NR} + 2.24M\right)$$

b) at radius 0.35 (D_p/2) for controllable pitch propellers

$$L_p T_p^{\,2} \geq \frac{21084300}{\sigma_u (0.65 + 0.7P_r/D_p)} \left(27.2 \frac{P_s}{NR} + 2.35M\right)$$

c) at the radius 0.6 (D_p/2)

$$L_p T_p^{\,2} \geq \frac{9316320}{\sigma_u (0.65 + 0.7P_r/D_p)} \left(27.2 \frac{P_s}{NR} + 2.86M\right)$$

where,

D_p = diameter of propeller [m]

L_p = length of the expanded cylindrical section of the blade, at the radius considered [mm]

M = ice torque as defined in 3.2.2

N = number of blades

P_r = propeller pitch at the radius considered, for solid propellers [m]

= 0.7 nominal pitch for controllable pitch propellers [m]

P_s = shaft power [kW]

R = propeller speed, [rev/min]

T_p = the corresponding maximum blade thickness [mm]

σ_u = specified minimum tensile strength of the material, [N/mm^2].

The blade thicknesses, however, are not to be less than that as per Pt.4, Ch.4, Sec.7.

3.2.4 Propeller blade minimum tip thickness

The blade tip thickness t, at the radius D/2 is to be determined by the following formulae:

Ice Class **HAT(B):**

$$t = (20 + 2D)\sqrt{\frac{490}{\sigma_u}}\ [mm]$$

Ice Classes **HT(B), HM(B)** and **Ha(B):**

$$t = (15 + 2D)\sqrt{\frac{490}{\sigma_u}}\ [mm]$$

where, D and are as defined in 3.2.3.

3.2.5 Intermediate blade sections

The thickness of other sections is to conform to a smooth curve connecting the section thicknesses as determined by 3.2.3 and 3.2.4.

3.2.6 Blade edge thickness

The thickness of blade edges is to be not less than 50 per cent of the derived tip thickness, t, measured at 1.25t from edge. For controllable pitch propellers this applies only to the leading edge.

3.2.7 Mechanisms for controllable pitch propellers

The strength of mechanisms in the boss of a controllable pitch propeller is to be 1.5 times that of the blade when a load is applied at the radius 0.9D/2 in the weakest direction of the blade.

3.2.8 Keyless propellers

When it is proposed to use keyless propellers, the fit of the propeller boss to the tailshaft will be specially considered.

3.2.9 Tailshafts

3.2.9.1 The diameter d_s at the aft bearing of the tailshaft fitted in conjuction with a solid propeller is to be not less than:

$$d_s = 1.08\ \sqrt[3]{\frac{\sigma_u\ L_p T p^2}{\sigma_y}}\ [mm]$$

where,

L_p and T_p = proposed width and thickness respectively of the propeller blade section at 0.25 (D_p/2) [mm]

σ_y = specified minimum yield stress of the material of the shaft, [N/mm^2]

σ_u = specified minimum tensile strength of the blade material, [N/mm^2].

3.2.9.2 The diameter, d_s at the aft bearing of the tailshaft fitted in conjunction with a controllable pitch propeller is to be not less than:

$$d_s = 1.15\ \sqrt[3]{\frac{\sigma_u L_p T p^2}{\sigma_y}}\ [mm]$$

where,

L_p and T_p = proposed width and thickness respectively of the propeller blade section at 0.35 (D_p/2) [mm].

3.2.9.3 The tailshaft diameter as derived from 3.2.9.1 or 3.2.9.2 is however not to be less than the diameter derived from Pt.4, Ch.4, Sec.6.

3.2.9.4 The shaft may be tapered at the forward end in accordance with Pt.4, Ch.4, Sec.6.

3.2.10 Intermediate and thrust shafts

The diameters of intermediate shafts and thrust shafts in external bearings are to comply with Pt.4, Ch.4.6, except for Ice Class **HAT(B)** ice strengthening where these diameters are to be increased by 10 per cent.

3.2.11 Reduction gearing

Where gearing is fitted between the engine and the propeller shafting, the gearing is to be in accordance with Pt.4, Ch.4, Sec.5 and is to be designed to transmit a torque, Y_i, determined by the following formula:

$$Y_i = Y + \frac{M\,I_h\,u^2}{I_l + I_h\,u^2}\ [kN-m]$$

where,

u = gear ratio

$$= \frac{\text{pinion speed}}{\text{wheel speed}}$$

I_h = mass moment of inertia of machinery components rotating at higher speed

I_l = mass moment of inertia of machinery components rotating at lower speed, including propeller with an addition of 30 per cent of entrained water

(I_h and I_l are to be expressed in the same units)

M = ice torque as defined in 3.2.2.

$$Y = 9.55 \frac{P}{R}$$

P and R are defined in 3.2.3.

3.2.12 Starting arrangements

In addition to complying with the requirements of Pt.4, Ch.4, where applicable, the capacity of the air compressors is to be sufficient for charging the air receivers from atmospheric to full pressure in half an hour for a ship with Ice Class **HAT(B)** where the propulsion engine has to be reversed for going astern.

3.2.13 Sea inlet chests and cooling water systems

The cooling water system is to be designed to ensure a supply of cooling water when navigating in Ice. For this purpose at least one cooling water inlet chest is to be arranged as follows:

a) The sea inlet chest is to situated near the centreline of the ship and well aft, if possible.

b) As guidance for design, the volume of the chest is to be about 1 [m^3], for every 750 [kW] engine output of the ship including the output of auxiliary engines necessary for the ship's service.

c) The chest is to be of sufficient height to allow ice to accumulate above the inlet pipe.

d) A recirculating connection from the cooling water overboard discharge line, capable of full capacity discharge, is to be led to the chest.

e) The net area through the grating at the shell opening is to be not less than four times the sectional area of the inlet pipe.

Where there are difficulties in meeting the requirements of (b) and (c), two smaller chests may be arranged for alternating intake and discharge of cooling water. The arrangement and location otherwise is to be same as above.

Heating coils may be installed in the upper part of the chest or chests.

Arrangements for circulating water from ballast tanks for cooling purposes may be useful as a reserve in ballast conditions but cannot be accepted as a substitute for sea inlet chests as described above.

3.2.14 Fire pumps in motor ships

In motor ships where clearing steam is not available, at least one of the fire pumps are to be provided with suctions from the cooling water inlet chest referred to in 3.2.13.

3.3 Ice class 'Ha'

3.3.1 Where the notation '**Ha**' is desired, the requirements of this Section, in addition to those for open water service, are to be complied with.

3.3.2 Main engine shafting, gearing and propellers

The diameters of the shafting and propeller blade thickness as required by the Rules for open water service are to be increased by the following percentages.

Tailshaft diameter (as required by Pt.4, Ch.4, Sec.6)	5%
Propeller blade thickness at root and at 60 per cent radius (as required by Pt.5, Ch.4, Sec.7)	8%
Keyless propeller, mean torque	15%

No increase in the diameter of crankshafts, thrustshafts or intermediate shafts is required.

The tailshaft may be tapered at the forward end in accordance with Pt.4, Ch.4, Sec.6.

3.3.3 Minimum propeller blade tip thickness

The tip thickness, t, of the blade at 95 per cent radius is to be not less than that obtained by the following formula:

$$T = 0.14\ (T_p + 57)\ \sqrt[3]{\frac{430}{\sigma_u}}\ \text{[mm]}$$

where,

T_p = blade root thickness required by 3.2.3 [mm]

σ_u = specified minimum tensile strength of material, [N/mm^2].

3.3.4 Blade edge thickness

The edges of the blades are to be suitably thickened for the operating conditions, but are to be not less than 50 per cent of the required tip thickness, t, measured at 1.25 t, from the edge. For controllable pitch propellers, this requirement need only be applied to the leading edges of the blades.

3.3.5 Ship-side valves

The sea inlet and overboard discharge valves which are situated at or below the maximum Load Line, are to be provided with low pressure steam or compressed air connection for clearing purposes.

When steam is not available for clearing, it is recommended that arrangements be made for supplying water for machinery cooling purposes by circulating from ballast tank(s) of adequate capacity, preferably situated in the double bottom. Such tank(s) must be used only for storage of water ballast or fresh water.

3.3.6 Cooling water lines

Connections are to be fitted between the cooling water overboard discharge lines and sea inlets for main and/or auxiliary engine cooling water systems so that warm water may be used to assist in maintaining the suction pipes free from ice.

Where the cooling water inlet valves are fitted to a common water box, the connections from the cooling water discharge lines may be led to the water box in a position as near as possible to the inlet valves.

3.3.7 Fire pumps in motor ships

In motor ships where clearing steam is not available, at least one of the fire pumps are to be provided with suctions from the main cooling water inlet pipe.

End of Chapter

Chapter 22

Vessels with Unattended Machinery Spaces

Contents

Section

Section 1

General

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to machinery spaces intended for unattended operation during normal service at sea and in port.

l.1.2 Cargo handling systems are not covered by the requirements of this Chapter.

1.1.3 The requirements of this Chapter are in addition to the requirements of Pt.4 of the Rules.

1.2 Class notation

1.2.1 Machinery installations complying with the requirements of this Chapter may be given the additional class notation SYJ.

1.3 Assumptions

1.3.1 The requirements of this Chapter are based on the assumptions that :

a) engineering staff can reach the engine room at short notice;

b) systematic maintenance and functional testing of instrumentation are performed and documented; and

c) the test equipment is kept on board. The equipment is to be sufficient for all tests specified in the instructions for systematic maintenance and function testing on board.

1.4 Plans and particulars

1.4.1 In addition to the plans and particulars required by Pt.4, Ch.7, the following plans and particulars are to be submitted for approval :

- location of automatic fire detectors, manual fire alarm controls and fire alarm bells;

- location of fire alarm system central unit, together with location of remote stop controls for fans, pumps, etc.;

- supply of electric power to fire alarm system;

- connection and arrangement of automatic stop system (if fitted) for ventilation fans;

- connection and arrangement of detector sections and warning actuators; and

- location and power supply arrangements of internal communication systems.

1.5 Signboards and instruction manuals

1.5.1 Instruction manuals are to be kept on board. One copy of the manuals is to be submitted for information. The manuals are to contain necessary instructions on :

- operation;
- testing;
- identification of faults;
- repairs;
- emergency operation; and
- systematic maintenance and function testing.

1.5.2 The plan for systematic maintenance and function testing is to show how components and systems are to be tested and what is to be observed during the tests.

1.5.3 On the bridge and the control stand in the engine room, instructions are to be fitted, stating routines to be carried out in connection with transfer to/from unmanned engine room and precautions to be taken at alarm condition.

1.6 Spares

1.6.1 It is advisable to keep on board spare parts for important, replaceable parts/units of the automatic control systems, monitoring systems, remote control systems and programmed control systems.
1.6.2 The quantity of spare parts is, preferably to be as recommended by the manufacturers, and sufficient to cover replacements necessary for at least one year's service. Spare parts should amount to 10 per cent, minimum one of each, of such components as:

- transducers;
- controllers;
- indicating instruments;
- printed circuit cards;
- actuators; and
- relays, fuses, lamps, etc.

1.6.3 Spare parts should preferably consist of complete units. However, solenoids, springs, gaskets and similar parts will be useful as substitute for complete units, if replacement of defective parts within the unit is easily made by the engine staff.

Section 2

System Design

2.1 General

2.1.1 The arrangements provided are to be such as to ensure that the safety of the ship in all conditions, including maneuvering, is equivalent to that of a ship having machinery spaces manned.

2.1.2 The extent of automation is to be sufficient for 24 hours of unattended engine room operation during normal service at sea and normal maneuvers. Normal maneuvers do not include emergency maneuvers, where alarm and safety limits may be exceeded.

2.1.3 Starting of engine plant and transfer to various operating modes may be accepted as manual operations, if the need for such actions will not arise at short notice.

2.2 Control locations

2.2.1 A system of alarm displays and controls is to be provided which readily ensures identification of faults in the machinery and satisfactory supervision of related equipment. This may be provided at a main control location or, alternatively at subsidiary control locations. In the latter case, a master alarm display is to be provided at the main control location showing which of the subsidiary control locations is indicating a fault condition.

2.2.2 Provision is to be made at the main control location, or subsidiary control locations as appropriate, for the operation of engineer's alarm which is to be clearly audible in the engineer's accommodation.

2.2.3 Provision is to be made at the main control location and any other subsidiary control location from which the main propulsion and auxiliary or associated equipment may be controlled to indicate which location is in control.

2.2.4 Remote control of propulsion machinery and associated equipment is to be possible from only one location at a time; at such locations interconnected control positions are permitted. The transfer of control between the navigating bridge and machinery spaces is to be possible only in the main machinery space or in the main machinery control room. Changeover between control locations is to be arranged so that it may be effected with the acceptance of the location taking control. The system is to be provided with interlocks or other suitable means to ensure effective transfer of control. The system is to include means to prevent the propelling thrust from altering significantly when transferring control from one location to another.

2.2.5 Under all sailing conditions, including maneuvering, the speed, direction of thrust and, if applicable, the pitch of the propeller are to be fully controllable from the bridge. Such remote control is to be performed by a single control device for each independent propeller, with automatic performance of all associated services, including, where necessary, means of preventing overload and prolonged running in critical speed ranges of propelling machinery.

2.2.6 Propulsion machinery orders from the navigating bridge are to be indicated in the main machinery control room or at the propulsion machinery control position as appropriate.

2.2.7 It is to be possible for all machinery essential for the safe operation of the ship to be controlled from a local position, even in case of failure in any part of the automatic or remote control systems.

2.2.8 The bridge control system is to be independent from the other transmission system; however, one control lever for both system may be accepted.

2.2.9 Operations following any setting of the bridge control device including reversing from the maximum ahead service speed in case of emergency are to take place in an automatic sequence and with time intervals acceptable to the machinery.

2.2.10 Instrumentation to indicate at least the following is to be fitted on the bridge :

a) Propeller speed;

b) Direction of rotation of propeller for a fixed propeller or pitch position for controllable pitch propeller;

c) Clutch position, where applicable; and

d) Shaft brake position, where applicable.

2.2.11 Means of control, independent of bridge control system, are to be provided on bridge to enable the watchkeeper to stop the propulsion machinery in an emergency.

2.2.12 Remote starting of the propulsion machinery is to be automatically inhibited if conditions exist which may hazard the machinery, e.g. shaft turning gear engaged, drop of lubricating oil pressure.

2.2.13 For steam turbines a slow-turning device should be provided which operates automatically if the turbine is stopped longer than admissible. Discontinuation of this automatic turning from the bridge must be possible.

2.2.14 Audible and visual alarms are to operate on the bridge, if the power supply to the bridge control system or the alarm system fails. Where practical, the preset speed and direction of thrust are to be automatically maintained until corrective action is taken.

2.3 Control systems

2.3.1 Automatic control systems are to keep all parameters within the limits for safe operation under all load conditions.

2.3.2 Expansion/compensating tanks are normally not to be automatically filled. If automatic filling of expansion/compensating tanks is arranged, an alarm is to be activated before such filling is started or at abnormal long or frequent operation.

2.3.3 Protection against flooding

1. Bilge wells in periodically unattended machinery spaces are to be located and monitored in such a way that the accumulation of liquids is detected at normal angles of trim and heel, and are to be large enough to accommodate easily the normal drainage during unattended period.

2. Where the bilge pumps are capable of being started automatically, means are to be provided to indicate when the influx of liquid is greater than the pump capacity or when the pump is operating more frequently than would normally be expected. In these cases, smaller bilge wells to cover a reasonable period of time may be permitted. Where automatically controlled bilge pumps are provided, special attention is to be given to oil pollution prevention requirements.

3. The location of the controls of any valve serving a sea inlet, a discharge below the waterline or a bilge injection system is to be so sited as to allow adequate time for operation in case of influx of

water to the space, having regard to the time likely to be required to reach and operate such controls. If the level to which the space could become flooded with the ship in the fully loaded condition so requires, arrangements are to be provided to operate the controls from a position above such level.

IR 2.3.3.3.1 'Bilge injection system' referred above is same as 'Emergency bilge suction' referred in Pt. 4, Ch. 3, Sec 2.7.4 which is used to discharge overboard large quantities of sea water accumulated in engine room bilges using the main circulating pump or another suitable pump as permitted by Pt. 4, Ch. 3, Sec 2.7.4.

IR 2.3.3.3.2 The requirements for the controls as referred in 2.3.3.3 above are not applicable to valves serving an emergency bilge system provided:
(1) The emergency bilge valve is normally maintained in a closed position,
(2) A non-return device is installed in the emergency bilge piping, and
(Note: A normally closed non-return valve with positive means of closing is considered to satisfy both (1) and (2) above.)
(3) The emergency bilge suction piping is located inboard of a shell valve(overboard valve) that is fitted with the control arrangements required by 2.3.3.3.

2.3.4 Starting air receivers are to be automatically filled, if the air consumption during normal operation at sea, not including maneuvering, can reduce the air pressure by 20 per cent or more in the course of 24 hours.

2.3.5 Control systems should be designed to "fail safe". The characteristics of the "fail safe" operation are to be evaluated on the basis not only of the control system and its associated machinery, but also the complete installation.

2.3.6 The arrangements are to be such that machinery may be operated with the automatic controls out of action. This may be achieved by manual control or redundancy arrangements within the control system. Instrumentation is to be provided at the local manual control locations to ensure effective operation of the machinery.

2.3.7 The design of the remote automatic control system is to be such that in the case of its failure an alarm will be given. Unless IRS considers it impracticable, the preset speed and direction of thrust of the propeller is to be maintained until local control is in operation.

2.3.8 The number of consecutive automatic attempts which fail to produce a start are to be limited to safeguard sufficient starting air pressure. An alarm is to be provided to indicate low starting air pressure set at a level which still permits starting operations of the propulsion machinery.

2.4 Alarm systems

2.4.1 An alarm system is to be provided indicating any fault requiring attention and is to :

a) be capable of sounding an audible alarm in the main machinery control room or at the propulsion machinery control location, and indicate visually each separate alarm function at a suitable position;

b) have a connection to the public rooms and to each of the engineers' cabins through a selector switch, to ensure connection to at least one of those cabins. Equivalent arrangements will be specially considered;

c) activate an audible and visual alarm on the navigating bridge for any situation which requires action by or attention of officer on watch;

d) as far as is practicable be designed on the fail-to-safety principle; and

e) activate an alarm in the engineers accommodation if an alarm function has not received attention locally within a limited time.

f) satisfy the environmental requirements of IRS Classification Notes “Type Approval of Electrical Equipment used for Control, Protection, Safety and Internal Communication in Marine Environment”.

2.4.2 The alarm system is to be continuously powered and is to have an automatic change-over to a stand-by power supply in case of loss of normal power supply.

2.4.3 Failure of the normal power supply of the alarm system is to be indicated by an alarm.

2.4.4 The alarm system is to be able to indicate at the same time more than one fault and the acceptance of any alarm is not to inhibit another alarm.

2.4.5 Acceptance at any of the positions referred to in 2.4.1(b) of any alarm condition is to be indicated at the positions where it was shown. Alarms are to be maintained until they are accepted and the visual indicators of individual alarms are to remain until the fault has been corrected, when the alarm system is to automatically reset to the normal operating condition.

2.4.6 Alarms associated with machinery, safety and control system faults are to be clearly distinguishable from other alarms (e.g. Fire, General alarm).

2.4.7 Where alarms are displayed as group alarms, provision is to be made to identify individual alarms at the main control location (if fitted) or alternatively at subsidiary control locations.

2.4.8 The alarm system should be designed with self-monitoring properties. Insofar as practical, any fault in the alarm system should cause it to fail to the alarm condition.

2.4.9 The alarm system is to be capable of being tested during normal machinery operation.

2.4.10 The alarm system is to be designed as far as practical to function independently of control and safety systems such that a failure or malfunction in these systems will not prevent the alarm from operating.

2.4.11 Disconnection or manual overriding of any part of the alarm system should be clearly indicated as long as the disconnection/manual override is in use.

2.4.12 Any alarm condition in the engine room is to activate an alarm in the watch-keeping engineer officer's cabin and dayroom. Acknowledgement in the cabin is to be indicated on the bridge when the engine room is unattended.

2.4.13 Audible and visual indications of machinery space alarms are to be relayed to the navigating bridge control location in such a way that the navigating officer of the watch is made aware when :

a) a machinery fault has occurred;

b) the machinery fault is being attended to; and

c) the machinery fault has been rectified.

2.4.14 Group alarms may be arranged in the bridge to indicate machinery faults, but alarms associated with faults requiring speed or power reduction or the automatic shut down of propulsion machinery are to be separately identified.

2.5 Safety systems

2.5.1 A safety system is to be provided to ensure that a serious malfunction in machinery or boiler operations, which presents an immediate danger, is to initiate the automatic shutdown of that part of the plant and that an alarm is to be given. Shutdown of the propulsion system is not to be automatically activated except in cases which could lead to serious damage, complete break down, or explosion. Where arrangements for overriding the shutdown of the main propelling machinery are fitted, these are to be such as to preclude inadvertent operation. Visual means are to be provided to indicate when the override has been activated.

2.5.2 The safety system is to be designed as far as practical to operate independently of the control and alarm system, such that a failure or malfunction in these systems will not prevent the safety system from operating.

2.5.3 Safety systems are to operate automatically in case of serious faults endangering the machinery, so that :

a) normal operating conditions are restored, e.g. by the starting of standby machinery; or

b) the operation of the machinery is temporarily adjusted to the prevailing conditions, e.g. by reducing the output of the machinery; or

c) the machinery is protected from critical conditions by shutting off the fuel or power supplies thereby stopping the machinery.

2.5.4 Safety systems for different items of the machinery plant are to be arranged so that failure of the safety system of one part of the plant is not to interfere with the operation of the safety system in another part of the plant.

2.5.5 The safety system should be designed to "fail safe". The characteristics of the "fail safe" operation are to be evaluated on the basis not only of the safety system and it's associated machinery, but also the complete installation.

2.5.6 When a safety system is activated, an audible and visual alarm is to be provided to indicate the cause of the safety action.

2.5.7 The safety system is to be provided with a manual reset.

2.5.8 The safety system is to be arranged with automatic changeover to a standby power supply in the event of a failure of the normal supply. The failure of the power supply to a safety system is to operate an audible and visual alarm.

2.6 Automatic start of pumps

2.6.1 Faults in the mechanical or electrical system of the running pump are not to inhibit automatic start of the standby pump.

2.6.2 Manual start and stop of the pumps are to be possible without activating the alarm for automatic start of the pump.

2.6.3 When a pump is standby, this is to be clearly indicated on the control panel by indicating lamps, etc.

2.7 Automatic start/connection of diesel generator units and essential auxiliaries for propulsion

2.7.1 Where the electrical power can normally be supplied by one generator, suitable load-shedding arrangements are to be provided to ensure the integrity of supplies to services required for propulsion and steering as well as the safety of the ship. In the case of loss of the generator in operation, adequate provision is to be made for automatic starting and connecting to the main switchboard of a stand-by generator of sufficient capacity to permit propulsion and steering and to ensure the safety of the ship with automatic restarting of the essential auxiliaries including, where necessary, sequential operations. IRS may dispense with this requirement for a ship of less than 1,600 tons gross tonnage, if it is considered impracticable.

2.7.2 If the electrical power is normally supplied by more than one generator simultaneously in parallel operation, provision is to be made, for instance by load shedding, to ensure that, in case of loss of one of these generating sets, the remaining ones are kept in operation without overload to permit propulsion and steering, and to ensure the safety of the ship.

2.7.3 Where stand-by machinery are required for other auxiliary machinery essential to propulsion, automatic change over devices are to be provided.

Above is applicable to stand-by machinery are required by the Rules for operation of:

a) oil engines for propulsion purposes,
b) steam turbines for propulsion purposes,
c) gas turbines for propulsion purposes,
d) controllable pitch propellers.

2.7.4 When several generator units have individual systems for automatic start and connection on to the main switchboard, each system is to be selectively fused (separate short circuit protection), and alarm is to be activated for voltage failure.

2.7.5 Automatic start attempts are to be limited in time to restrict consumption of starting energy.

2.7.6 Tachometer feedback to the starting system is to be arranged so that broken mechanical pinions or external electrical connections do not lead to stop of a running generator unit. Neither are such faults to inhibit automatic stop or alarm functions.

2.7.7 Manual start and stop of generator are not to activate alarm.

2.7.8 The generator circuit breaker is to be provided with automatic wind up of the closing spring of the breaker.

2.7.9 Simultaneous connection of generators on to the main switchboard is not to be possible.

2.7.10 If there is no arrangement for automatic synchronization, paralleling and load sharing, connection is only to be possible when auxiliary contacts on the generator circuit breakers show directly that all generators are disconnected from the main switchboard.

2.7.11 When a generator unit is standby, this is to be indicated on the control panel.

2.7.12 The voltage of a generator being connected on to a de-energized switchboard is to be sufficiently high for safe operation of all connected circuits.

2.7.13 No more than one attempt of automatic connection on to a de-energized switchboard is permitted.

2.7.14 Systems with automatic synchronization, connection, and load sharing are to be designed so that deviations in voltage, frequency, and phase at the instant of connection are within adequate safety limits for generator and engine.

2.7.15 Means for manual synchronization and paralleling are to be provided.

2.7.16 When automatic start of the standby unit is caused by reduction of voltage or frequency below the criteria for automatic connection, the running unit is to be stopped when standby unit is ready for connection.

2.7.17 Systems with automatic start of the standby unit at heavy load on running units are to be arranged with adequate delay to prevent false start attempts, e.g. caused by short load peaks.

2.7.18 The battery supplying the diesel engine start system is to have at least twice the capacity required for maximum load for half an hour for all consumers connected to the system.

2.7.19 Batteries are to be continuously charged (trickle charge) from a charge rectifier having sufficient capacity to supply the sum of the trickle charge current, the current according to the fuse rating of the largest consumer, and the normal load current for all other consumers. A lower charge rectifier capacity may be approved, provided the distribution system is monitored for ground faults. The capacity is not to be less than the sum of the trickle charge current plus average normal load during 24 hours for all consumers with a 10 per cent allowance in addition.

2.8 Automatic stop of auxiliary engines

2.8.1 The system for automatic stop and alarm is to be selectively fused (separate short circuit protection). Similarly, automatic stop circuits for individual units are to be selectively fused. An alarm is to be activated for voltage failure.

2.8.2 The safety system is to be arranged so that a single open circuit in wiring between sensors and control unit, or between control unit and actuators, does not cause unintentional stop.

2.9 Automatic stop of propulsion machinery

2.9.1 Propulsion machinery is defined as all machinery which will cause loss of propulsion function if stopped, with the exception of main boilers.

2.9.2 The safety system is to be arranged so that a single open circuit in the wiring between sensors and control unit, or between control unit and actuators, does not cause unintentional stop.

2.9.3 Voltage failure behind the last fuse in the system is to activate an alarm.

2.9.4 Separate automatic stop system, whenever practicable, is to be arranged for each unit in multi-unit propulsion plants. The requirements of 2.9.2 could be waived if the maneuvering ability is maintained after shut-down of one propulsion unit.

2.9.5 All parameters which may cause automatic stop are normally to activate an alarm prior to causing a shut- down.

2.10 Automatic stop of oil fired auxiliary boilers

2.10.1 Connections between sensors and control unit are to be based upon normally closed contacts, so that an open circuit will lead to shut-off of the oil supply.

2.10.2 The parameter causing an automatic stop is to be identified on the control panel.

2.11 Re-establishment of propulsion after blackout

2.11.1 Automatic restart after a blackout is to be arranged for all components which are necessary for re- establishment of propulsion from the bridge.

2.11.2 In multi-unit installations, where stopping of one unit will not cause loss of propulsion, the requirements of 2.11.1 need not be complied with.

2.11.3 If necessary, restart is to be arranged in a sequence ensuring that the power system or other systems are not overloaded, and that most important components are started first.

2.12 Communications

2.12.1 A reliable means of vocal communication is to be provided between the main machinery control room or the propulsion machinery control position as appropriate, the navigating bridge and the engineer officers' accommodation.

2.12.2 It is to be possible at any time (including during blackout) to be able to communicate with the engineer officers, from the bridge and from the engine room.

2.12.3 For ships over 2000 gt., at least 4 simultaneous voice connections are to be possible. Alternatively the connection between the bridge and the engine rooms is to have priority above other connections.

2.13 Fire detection and alarm systems

2.13.1 A fire detector indicator panel is to be located in the navigating bridge area, or in such a position that a fire in the machinery spaces will not render it inoperative. The panel is to indicate the source of the fire in accordance with arranged fire zones by means of a visual signal.

2.13.2 An audible fire alarm is to be provided having a characteristic tone which distinguishes it from any other alarm system required by the Rules. The audible fire alarm is to be audible on all parts of the navigating bridge, the fire control location, the accommodation areas and the machinery space.

2.13.3 Facilities are to be provided in the detecting system to manually initiate the fire alarm from the following locations :

a) positions adjacent to entrances to engine and boiler rooms;

b) navigating bridge;

c) control location in engine room; and

d) fire control location.

2.13.4 The alarm system is to be designed with self monitoring properties. Power or system failures are to initiate an audible alarm distinguishable from the fire alarm. This alarm may be incorporated in the machinery alarm systems.

2.13.5 Detector heads and manual call points are to be of a type approved by IRS.

2.13.6 Detector heads are to be located in the machinery space so that all potential fire outbreak points are guarded. A combination of detector types is recommended in order that the system will react to all possible fire characteristics.

2.13.7 When fire detectors are provided with means to adjust their sensitivity, the arrangements are to be such that the set point can be fixed and readily identified.

2.13.8 When it is intended that a particular section or detector is to be temporarily switched off, this state is to be clearly indicated. Reactivation of the section or detector is to be performed automatically after a preset time.

2.13.9 The fire detector heads are to be of a type which can be tested. Facilities are to be provided on the fire control panel for functional testing of the system.

2.13.10 It is to be demonstrated to the Surveyor's satisfaction that detector heads are so located that air currents will not render the system ineffective at sea and in port.

2.13.11 Also refer to Pt.6, Ch.3, Sec.1.4 for other requirements.

Section 3

Requirements for Monitoring

3.1 Extent of monitoring

3.1.1 The monitoring system is to cover machinery and equipment having functions necessary for the safety and maneuverability of the ship.

3.1.2 When alarm and automatic actions (safety actions) are required for one failure condition, alarm is to be activated first.

3.1.3 The extent of monitoring required for internal combustion engines used for propulsion is given in Table 3.1.1. and 3.1.2. Requirements for steam turbine plants used for propulsion are given in Table 3.1.3.

3.1.4 In case of multi-engine propulsion plants, automatic start of standby pump is not required in auxiliary systems which are separate for each engine or group of engines.

3.1.5 The extent of monitoring required for shafting and propeller plant is given in Table 3.1.4.

3.1.6 The extent of monitoring required for electrical power generating plant is given in Table 3.1.5.

3.1.7 The extent of monitoring required for steam generating plant is given in Table 3.1.6.

3.1.8 The extent of monitoring required for tanks is given in Table 3.1.7.

3.1.9 The extent of monitoring required for miscellaneous items is given in Table 3.1.8.

Table 3.1.1 : Cross-Head Diesel Engines					
	Gr 1 (Common sensor)			**Gr 2**	**Gr 3**
Monitored parameters for cross-head diesel engines	**Remote Indication**	**Alarm activati on**	**Slow down with alarm**	**Automatic start of standby pump with alarm**	**Shut down with alarm**
1.0 Fuel oil system					
Fuel oil pressure after filter (engine inlet)	x	low		x	
Fuel oil viscosity before injection pumps or Fuel oil temp before injection pumps		high low			
Leakage from high pressure pipes		x			
Level of fuel oil in daily service tank[1]		low			
Common rail fuel oil pressure		low			
2.0 Lubricating oil system					
Lub oil to main bearing and thrust bearing, pressure	x	low	x	x	x
Lub oil to crosshead bearing pressure[2]	x	low	x	x	x
Lub oil to camshaft pressure[2]		low		x	x
Lub oil to camshaft temp[2]		high			
Lub oil inlet temp		high			
Thrust bearing pads temp or bearing outlet temp		high	x		x
Main, crank, crosshead bearing, oil outlet temp or Oil mist concentration in crankcase[3]		high	x		
Flow rate cylinder lubricator. Each apparatus		low	x		
Level in lubricating oil tanks[4]		low			
Common rail servo oil pressure		low			
3.0 Turbocharger system					
Turbocharger lub oil inlet pressure[9]		low			
Turbocharger lub oil outlet temp each bearing[10]		high			
Speed of turbocharger	x				
4.0 Piston cooling system					
Piston coolant inlet pressure[5]		low	x	x	
Piston coolant outlet temp each cylinder		high	x		
Piston coolant outlet flow each cylinder[8]		low	x		
Level of piston coolant in expansion tank		low			

Table 3.1.1 : (Contd.)					
	Gr 1 (Common sensor)			Gr 2	Gr 3
Monitored parameters for cross-head diesel engines	**Remote Indication**	**Alarm activation**	**Slow down with alarm**	**Automatic start of standby pump with alarm**	**Shut down with alarm**
5.0 Sea water cooling system					
Sea water pressure		low		x	
6.0 Cylinder fresh cooling water system					
Cylinder water inlet pressure		low	x	x	
Cylinder water outlet temp (from each cylinder) or Cylinder water outlet temp (general)[6]		high	x		
Oily contamination of engine cooling water system[7]		x			
Level of cylinder cooling water in expansion tank		low			
7.0 Starting and control air systems					
Starting air pressure before main shut-off valve	x	low			
Control air pressure		low			
Safety air pressure		low			
8.0 Scavenge air system					
Scavenge air receiver pressure	x				
Scavenge air box temp (fire)		high	x		
Scavenge air receiver water level		high			
9.0 Exhaust gas system					
Exhaust gas temp after each cylinder	x	high	x		
Exhaust gas temp after each cylinder. Deviation from average.		high			
Exhaust gas temp before each T/C	x	high			
Exhaust gas temp after each T/C	x	high			
10.0 Fuel valve coolant					
Pressure of fuel valve coolant		low		x	
Temperature of fuel valve coolant		high			
Level of fuel valve coolant in expansion tank		low			
11.0 Engine speed/direction of rotation.	x				
Wrong way		x			
12.0 Engine overspeed					x
13.0 Control-Safety-Alarm system power supply failure		x			

1 High-level alarm is also required if no suitable overflow arrangement is provided.

2 If separate lub oil systems are installed.

3 Slow down with Alarm is to be provided for Engines of 2250 [KW] and above or having cylinders of more than 300 [mm] bore.

4 Where separate lubricating oil systems are installed (e.g. camshaft, rocker arms, etc.), individual level alarms are required for the tanks.

5 The slow down is not required if the coolant is oil taken from the main cooling system of the engine.

6 Where one common cooling space without individual stop valves is employed for all cylinder jackets.

7 Where main engine cooling water is used in fuel and lubricating oil heat exchangers.

8 Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted.

9 Unless provided with a self-contained lubricating oil system integrated with the turbocharger.

10 Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer’s instructions may be accepted as an alternative.

Table 3.1.2 : Trunk-Piston Engines

	Gr 1 (Common Sensor)			**Gr 2**	**Gr 3**
Monitored parameters for trunk-piston diesel engines	**Remote Indication**	**Alarm activation**	**Slow down with alarm**	**Automatic start of standby pump with alarm**	**Shut down With alarm**
1.0 Fuel oil system					
Fuel oil pressure after filter (engine inlet)	x	low		x	
Fuel oil viscosity before injection pumps or Fuel oil temp before injection pumps[1]		high low			
Leakage from high pressure pipes		x			
Level of fuel oil in daily service tank[2]		low			
Common rail fuel oil pressure		low			
2.0 Lubrication oil system					
Lub oil to main bearing and thrust bearing, pressure	x	low		x	x
Lub oil filter differential pressure	x	high			
Lub oil inlet temp	x	high			
Oil mist concentration in crankcase[3]		high			x
Flow rate cylinder lubricator. Each apparatus		low	x		
Common rail servo oil pressure		low			

Table 3.1.2 : (Contd.)					
	Gr 1 (Common Sensor)			Gr 2	Gr 3
Monitored parameters for trunk-piston diesel engines	**Remote Indication**	**Alarm activation**	**Slow down with alarm**	**Automatic start of standby pump with alarm**	**Shut down With alarm**
3.0 Turbocharger system					
Turbocharger lub oil inlet pressure[5]	x	low			
Turbocharger lub oil temperature each bearing[8]		high			
4.0 Sea Water cooling system					
Sea Water pressure	x	low		x	
5.0 Cylinder fresh cooling water system					
Cylinder water inlet pressure or flow	x	low	x	x	
Cylinder water outlet temp (general)[6]	x	high	x		
Level of cylinder cooling water in expansion tank		low			
6.0 Starting and control air systems					
Starting air pressure before main shut-off valve	x	low			
Control air pressure	x	low			
7.0 Scavenge air system					
Scavenge air receiver temp		high			
8.0 Exhaust Gas system					
Exhaust gas temp after each cylinder[7]	x	high	x		
Exhaust gas temp after each cylinder. Deviation from average[7]		high			
9.0 Engine speed	x				
10.0 Engine overspeed					x
11.0 Control-Safety-Alarm system power supply failure		x			

1 For heavy fuel oil burning engines only.

2 High-level alarm is also required if no suitable overflow arrangement is provided.

3 Alarm and automatic shut off is to be provided for Engines of 2250 [KW] and above or having cylinders of more than 300 [mm] bore. One oil mist detector for each engine having two independent outputs for initiating the alarm and shut-down would satisfy the requirement for independence between alarm and shut-down system.

4 If necessary for the safe operation of the engine.

5 Unless provided with a self-contained lubricating oil system integrated with the turbocharger.

6 Two separate sensors are required for alarm and slow down.

7 For engine power > 500 kW/cyl.

8 Where outlet temperature from each bearing cannot be monitored due to the engine/ turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.

Table 3.1.3 : Steam Turbine Plants

System		**Required monitoring (stated by an x)**		**Comments**
		Alarm	**Automatic start of standby pump with alarm**	
Lubricating oil inlet	Temperature, high	x		
	Pressure, low	x		Independent of safety system
	Pressure, low		x	
	Pressure, low	x		Automatic shut down
	Filter differential pressure, high	x		
Bearings, turbine and gear	Temperature, high			
Lubricating oil	Level, low	x		In gravity tank
Gland steam	Pressure, high	x		
	Pressure, low	x		
	Exhaust fan, stopped	x		
Hydraulic system	Pressure, low			If separate system
	Pressure, low		x	If failure results in loss of maneuverability
Turbine slow-turning arrangement	Failure	x		
Rotor	Axial displacement, high	x		Turbine shut down
Vibration	Level, high	x		
Condensate system	Level, high	x		
	Level, high		x	
	Level, high	x		Turbine shut down
	Level, low	x		If non-cavitating condensate pumps
	Vacuum, low	x		
	Vacuum pump, stopped		x	
	Vacuum, low	x		Turbine shut down
	Salinity, high	x		
Cooling water	Flow, low		x	

Table 3.1.4 : Monitoring of Shafting and Propeller Plant

System		Required monitoring (stated by an x): Alarm	Required monitoring (stated by an x): Automatic start of standby pump with alarm	Comments
Shafting	Temperature, thrust bearing, high	x		Automatic or manual reduction, see 3.1.14. Two sensors for diesel engine built in thrust bearing and for steam turbine plants
	Temperature, shaft bearing, high	x		Shaft power ≥ 1500 [kW]. Sensor to be located near the bearing surface
	Temperature, stern tube bearing, high	x		Shaft power ≥ 15000 [kW]. Sensor to be located near the bearing surface at the area of highest load
	Level, stern tube lubricating oil gravity tank, low	x		
Controllable pitch propeller	Pressure, servo oil, low	x		
	Pressure, servo oil, low		x	
	Temperature, servo oil, high	x		Shaft power ≥ 1500 [kW]
Gear	Pressure, lubricating oil inlet, low	x		
	Pressure, lubricating oil inlet, low		x	
	Pressure, lubricating oil inlet, low			Automatic or manual stop, see 3.1.11
	Temperature, lubricating oil, high	x		
Hydraulic coupling	Pressure, oil, low	x		If separate system
	Pressure, oil, low		x	If failure results in loss of maneuverability

Table 3.1.5 : Monitoring of Electric Power Generating Plant				
System		Required monitoring (stated by an x)		Comments
		Alarm	Automatic shut down of prime mover with alarm	
Generators driven by trunk piston IC engines	Lubricating oil pressure, low	x	x	
	Lubricating oil temperature, high	x		
	Fuel oil leakage from high pressure pipes	x		
	Oil mist concentration in crank case, high[1]	x	x	
	Pressure or flow of cooling water, low	x		
	Temperature of cooling water or cooling air, high	x		
	Level in cooling water expansion tank, low	x		If not connected to main system
	Level in fuel oil daily service tank, low	x		
	Starting air pressure, low	x		
	Over speed activated		x	
	Fuel oil viscosity before injection pumps or fuel oil temp before injection pumps, low/ high	x		For heavy fuel oil burning engines only
	Exhaust gas temperature after each cylinder, high	x		For engine power above 500 kW/cyl
	Common rail servo oil pressure, low	x		
	Common rail fuel oil pressure, low	x		
	Voltage, high	x		
	Voltage, low	x		
	Frequency, low	x		
	Disconnection of non-essential consumers	x		
	1. Alarm and automatic shut off is to be provided for Engines of 2250 [KW] and above or having cylinders of more than 300 [mm] bore. One oil mist detector for each engine having two independent outputs for initiating the alarm and shut-down would satisfy the requirement for independence between alarm and shut-down system.			
Steam turbine	Temperature, lubricating oil, high	x		
	Pressure, lubricating oil inlet, low	x		Independent of safety system
	Pressure, lubricating oil inlet, low		x	
	Pressure, condenser, high	x		
	Pressure, condenser, high		x	
	Pressure, steam inlet line, low	x		
	Axial displacement rotor, large		x	Multistage turbines

Table 3.1.6 : Monitoring of Steam Generating Plant				
System		**Required monitoring (stated by an x)**		**Comments**
		Alarm	**Automatic shut down of boiler with alarm**	
Main Steam and Feed Water Installation				
Boiler water	Level, high	x		
	Level, high	x		Turbine shut down
	Level, low	x		Independent of safety system
	Level, low		x	
Water circulation	Stopped		x	Forced circulation boilers
Combustion air supply	Fan stopped		x	
Uptake gas	Temperature, high	x		For fire detection
Fuel oil	Pressure, low	x		
	Pressure, low			Automatic start of standby pump with alarm
Fuel oil temperature or viscosity	Heavy oil, high	x		
	Heavy oil, low	x		
Oil burner	Pressure of atomizing medium, low	x		
Steam	Pressure, high	x		
	Pressure, low	x		Turbine slow down
	Temperature, high	x		
Ignition/flame	Ignition/flame failure		x	Separate monitoring and fuel shutoff for each burner
Feed water system	Atmospheric tank level, high	x		
	Atmospheric tank level, low	x		
	Deaerator level, high	x		
	Deaerator level, low	x		
	Deaerator pressure, high	x		
	Deaerator pressure, low	x		
Feed water	Temperature, high	x		
	Pressure, low	x		
	Pressure, low			Automatic start of standby pump with alarm
High pressure feed water heaters	Level, high	x		
Fresh water generator	Salinity, high	x		Automatic stop of fresh water generator

Table 3.1.6 : (Contd.)				
System		**Required monitoring (stated by an x)**		**Comments**
		Alarm	**Automatic shut down of boiler with alarm**	
Auxiliary Boiler Plant				
Non-dual pressure boiler	Water level, high	x		
	Water level, low	x		Independent of safety system
	Water level, low		x	
Dual pressure boilers	Water level primary system, low	x		Independent of safety system
	Primary system, low		x	
	Secondary system, high	x		
	Secondary system, low	x		
Water circulation	Stopped		x	Forced circulation boilers
Fuel oil temperature or viscosity	Heavy oil, high	x		
	Heavy oil, low	x		
Steam	Pressure, high	x		
	Pressure, high		x	When the automatic control system does not cover the entire load range from zero load
	Temperature, high	x		For superheated steam ≥ 350°C
Feed water	Salinity, high	x		Boiler pressure ≥ 20 bar
Condenser	Pressure, high	x		
Ignition/flame	Failure		x	Separate monitoring and fuel shut off for each burner

Table 3.1.7 : Monitoring of Tanks		
Item	**Alarm**	**Comments**
Sludge and drain tanks, level high	x	All tanks arranged with automatic filling are to have alarm for both high and low level
Service tanks, level, low	x	
Expansion tanks, level low	x	
Circulating tanks, level low	x	

Table 3.1.8 : Monitoring of Miscellaneous Items

Item	Alarm	Comments
Bilges and bilge wells		
Engine room, level high	x	2 independent alarm circuits, minimum 2 detectors
Purifiers		
Lubricating oil inlet, temperature, high	x	
Fuel oil inlet, temperature high	x	
Fuel oil inlet, temperature low	x	For heavy fuel oil
Water seal, loss	x	
Alarm and safety systems, power failure	x	Electric, pneumatic, hydraulic
Remote control system, power failure	x	
Steering gear		
Electric motors, stopped	x	Manual start of standby motor from the bridge, alternatively automatic start with alarm

3.1.10 Proposals for extent of monitoring, different from those specified in Table 3.1.1 to Table 3.1.6, may be accepted provided these are shown to be as effective.

3.1.11 The fault conditions listed below are to effect an alarm requiring manual stop or alternatively automatic stop:

- lubricating oil pressure, inlet engine, low;
- lubricating oil pressure, inlet gear, low;
- thrust bearing temperature, high;
- crankcase explosive conditions for medium and high speed engines (for cylinder dia > 300 [mm] or engine power ≥ 2250 kW).

For transmitters for propulsion engines in Table 3.1.1, refer Note 7) in Table 3.1.1.

The alarm for gear is to have separate transmitter and in addition to the transmitters required by Table 3.1.4.

IRS may permit overriding of auto shut down provided consequences of overriding auto shut down are established and documented.

3.1.12 Automatic stop of single engine plant will be accepted only if the engine can be restarted from the bridge. However, automatic stop by overspeed and low lubricating oil pressure may be accepted without starting possibility from the bridge.

3.1.13 For multi-engine plants, canceling of automatic stop is not required if maneuverability of the vessel is maintained.

3.1.14 The fault conditions listed below are to cause an alarm requiring manual load reduction or alternatively automatic load reduction :

- lubricating oil pressure inlet engine, low;
- lubricating oil pressure inlet gearbox, low;
- cylinder lubrication flow, low;
- thrust bearing temperature, high;
- cooling medium pressure, inlet engine, low;
- cooling medium pressure, inlet piston, low;
- cooling medium flow, outlet pistons, low;
- cooling medium temperature outlet engine, high;
- scavenging belt temperature, high (fire); and
- crankcase explosive conditions for low speed engines (for cylinder dia > 300 [mm] or engine power ≥ 2250 kW).
- exhaust gas temperature outlet of each cylinder, high.

3.2 Electric power supply

3.2.1 Means are to be provided to avoid overloading of supply units.

3.2.2 The ship's main power supply is to be arranged according to one of the following methods :

- In ships where one generator is sufficient to cover normal load at sea there is to be an arrangement for automatic start and connection to the main switchboard of a standby generator. Start and connection are to be completed within 30 seconds;

- In ships where more than one generator is necessary to cover normal load at sea, there is, in order to maintain maneuverability, to be an arrangement for necessary tripping non-essential consumers in case of disconnections of, or failures which will lead to disconnection of a generator.

3.2.3 Standby units are normally to have separate cooling water and lubricating oil pumps. Alternatively, automatic start of standby pumps is to be arranged when they also serve other generating sets.

3.2.4 In the event of automatic start of standby power supply unit, automatic start of essential machinery is to follow in a pre-determined sequence. Units necessary for maneuvering of the ship are regarded as essential machinery. Starting air compressors, bilge, ballast and fire pumps need not be included.

3.2.5 When the maneuverability of the ship is independent of electric power, the requirements of 3.2.3 and 3.2.4 do not apply.

3.2.6 For essential consumers having power supply from the lighting system, precautions against power failure are to be similar to those taken for units having power supply from the main generators, e.g. the following means may be applied:

- adequate automatic emergency lighting for access to standby transformer for the lighting system and operating gear for manual connection;

- automatic connection of standby transformer;

- parallel connection of a sufficient number of transformers, and arrangement for selective disconnection;

- automatic connection of emergency source of power; and
- dividing the system in two or more circuits with automatic switch over.

In this context, essential consumers are units and equipment necessary for maneuvering of the ship, including navigation lights and sufficient lighting (either as part of the normal lighting or as separate emergency lighting) in the engine room, on the bridge, in the chartroom, in all passageways and stairways of the accommodation.

Section 4

Vessels fitted with Internal Combustion Propulsion Engines of less than 1000 [kW]

4.1 General

4.1.1 The requirements of this section are applicable to internal combustion propulsion engines of less than 1000 [kW], in lieu of the requirements specified in Section 3. Monitoring of parameters listed in 4.2 will normally be required. Other combinations of measuring points other than those listed may be accepted, when the chosen monitoring can detect fault conditions in an equivalent satisfactory manner.

4.1.2 The limitations of installations in ships with propulsion machinery of less than 1000 [kW] apply to the extent of monitoring only. The system arrangement is to be in accordance with Sec.2, unless otherwise specially stated.

4.2 Alarm system

4.2.1 Alarm is to be activated for the following fault conditions:

- fire in engine room;
- bilge level, high;
- variable pitch propeller, servo oil pressure, low;
- reduction gearing, lubricating oil pressure, low;
- power failure for alarm and remote control systems;
- main engine lubricating oil pressure, low;
- main engine cooling water (sea and fresh water) pressure, low. Indication of cooling water pressure on the bridge will be accepted as an alternative to alarms;

- main engine cooling water temperature, high;
- main engine cooling water expansion tank level - low; and
- low lubricating oil pressure and high cooling water temperature for electric power generating plants greater than 35 [kW].

4.3 Arrangements on bridge

4.3.1 In the event of fault condition the parameters, required to be monitored as per 4.2, are to activate individual or groupwise alarm signals on the bridge.

4.3.2 The following parameters are to be indicated on the bridge:

- rpm;
- propeller pitch (controllable pitch propeller);
- starting air pressure (reversible engine);
- direction of rotation (reversible engine);
- lubricating oil pressure for main engines and reduction gearing. This indication may be omitted if the pressure is monitored in accordance with the requirements of Sec.3.

4.4 Electric power supply

4.4.1 When the maneuverability of the ship is dependent on electric power, precautions are to be taken to avoid power supply units from being overloaded.

Section 5

Precautions against Fire

5.1 Oil fuel systems

5.1.1 Fuel oil injection pipes on all engines, irrespective of cylinder bore, are to be effectively shielded and secured. Safe drainage is to be provided for the leak- off oil.

5.1.2 Oil purifiers, burner units, and similar equipments, are to be efficiently shielded in order to prevent oil spray and leakages from reaching electric motors, hot surfaces, etc.

5.1.3 Also refer Pt.6. Ch.2, 1.2.5.

5.2 Fire detection

5.2.1 Fire detectors are to be fitted in the machinery spaces. All potential fire outbreak points are to be effectively guarded. The fire detection systems as well as number and location of detectors are subject to approval in each case.
A mixture of temperature and smoke/ionization detectors is advised. Flame detectors should be used to cover large spaces, e.g. over the main engine. The location and minimum number of detectors should preferably be as follows:

a) one detector for each internal combustion engine, boiler front, oil purifier installation, electric power distribution board and for each separate room in machinery spaces;

b) if temperature detectors are used exclusively, detectors should be fitted under all horizontal surfaces exceeding 10 [m^2] with a maximum distance of 5 [m] between detectors;

c) if smoke/ionization detectors are used exclusively, the number of detectors should not be less than -

$$0.03.L.B$$

L = total length of machinery spaces [m];

B = total breadth of machinery spaces [m];

d) the air flow in the machinery spaces under normal ventilation condition should be considered when the location of smoke/ionization detectors is considered.

5.2.2 Heat detectors only are not accepted for fire detection in the engine room.

5.2.3 The fire detectors are to be arranged in sections. There should be at least two sections for ships above 5000 gt.

5.3 Fire detector indicator panel

5.3.1 A fire detector indicator panel is to be located in the navigating bridge area, the fire control location or in such a position that a fire in the machinery spaces will not render it inoperative. The panel is to indicate the source of fire in accordance with arranged fire zones by means of a visual signal.

Section 6

Testing of the Plant on Board

6.1 General

6.1.1 After installation of the plant has been completed, function testing of the plant is to be carried out in the presence of the Surveyors.

6.1.2 Only after all work in connection with adjustments and starting of the various units of the plant has been completed, sea trials are to be carried out. The sea trials are to include at least 4 hours of continuous operation with unattended machinery spaces. Agreement is to be made in advance in each case for the personnel that will be present in the control room.

6.1.3 The builders are to prepare a detailed test programme. The test programme is to be kept onboard, all filled in and signed by the Surveyors.

6.1.4 If required by the Surveyor, vibrations and temperatures of exposed units are to be measured. If it is found that a unit is subjected to strains beyond the limits specified for it, precautions are to be taken to improve the conditions.

6.1.5 Recording of important automatically controlled parameters may be required as part of the testing.

6.2 Monitoring systems

6.2.1 Failure conditions are to be simulated as realistically as possible, preferably by letting the monitored parameters exceed the alarm and safety limits. The alarm and safety limits are to be recorded in the test programme.

6.2.2 Any calibrations of sensors prior to installation onboard are to be approved by the Surveyor.

6.3 Automatic and remote control systems

6.3.1 Automatic control systems are to be tested by varying the parameters having effect upon the controlled process. As far as practicable it is to be verified that all normal control ranges are covered.

6.3.2 All tests included in the test programme for the remote control system are to be carried out without any manual assistance from the engine room, and all systems are to be in operation as normal for unattended periods.

6.4 Blackout test

6.4.1 During bridge control at about half speed ahead, a failure is to be simulated to cause automatic stop of electric power generator.

6.4.1.1 For installations with automatic start and connection of standby units, it is to be ensured that the automatic start of standby power supply unit and machinery necessary for maneuvering of the ship from the bridge is effected without manual intervention in the engine room.

6.4.1.2 For installations with two or more generator units run in parallel at a time, it is to be ensured that the stopped unit is automatically disconnected from the switchboard, and that the capacity of the remaining running unit(s) is adequate for propulsion and steering functions after automatic tripping of non-essential consumers.

End of Chapter

Chapter 23

Refrigerated Cargo Installations

Contents

Section 1

General

1.1 Class notation

1.1.1 On application from an Owner, refrigerated cargo installations which comply with the requirements of this Chapter will be assigned an appropriate notation. The class notations assigned, together with particulars of the installation, will be entered in the Register Book. The class will be maintained so long as the installation is found, at the prescribed periodical surveys, to be in a fit and efficient condition and in accordance with requirements of the Rules. Any damage or breakdown which could affect the temperature assigned or maintenance of class should be reported to IRS at the earliest practical opportunity.

1.1.2 The class notation generally assigned will be 'HY' followed by the minimum temperature(s) approved by IRS for the installation with the maximum sea temperature stated e.g. 'to maintain temperature - 20°C in the lower and 0°C in the upper chamber with sea temperature of 32°C maximum'.

1.1.3 For refrigerated cargo installations aboard container ships with approved refrigerating plant and arrangements to supply refrigerated air through ducting to insulated containers, the class notation assigned will additionally specify the maximum number and characteristics of the containers for which the plant is approved, e.g., 'to supply refrigerated air at a temperature of - 20°C to certified 600 insulated containers with an average thermal transmittance per container of 27 W/C with sea temperature 32°C maximum'.

1.1.4 On application from an Owner, consideration will be given by IRS to an alternative temperature notation being assigned to that appearing in the Register Book. The temperature at which the cargo is to be carried is not the responsibility of IRS.

1.1.5 Installations constructed under Special Survey in accordance with the requirements of this Section will be eligible for the distinguishing mark ++ before class notation. In other cases, the mark will not be assigned.

1.1.6 If the refrigerating plant is found to be capable of cooling down fruit in general or a catch of fish the symbol * may be added after the class notation.

1.1.7 IRS will give consideration to ships engaged on voyages of short duration, to installations of small capacity, or to other special circumstances. In such cases, the class may include a service limitation or other restriction.

1.1.8 The requirements of Pt.1 of the Rules, regarding reclassification and withdrawal of class respectively, apply also to refrigerated cargo installations.

1.2 Survey during construction

1.2.1 New installations intended for classification are to be constructed and tested under Special Survey in accordance with the requirements of this Chapter.

1.2.2 The materials used in the construction are to be manufactured and tested in accordance with the requirements of Pt. 2. Materials for which provision is not made in Pt.2 may be accepted, provided that they comply with an approved specification and such tests as may be considered necessary.

1.2.3 From the commencement of the construction and installation of the refrigerating plant and of the insulation and fitting out of the cargo chambers, to the testing of the completed installation, the Surveyors are to examine the materials and workmanship and are to indicate at the earliest opportunity, and require the rectification of, any items not in accordance with the Rules or the approved specifications and plans or any material, workmanship or arrangement found to be defective or unsatisfactory.

1.3 Refrigerants

1.3.1 These Rules are applicable to the following primary refrigerants :

- R 717 Ammonia
- R 22 Monochlorodifluoromethane.

1.3.2 Proposals to use other refrigerants will be specially considered on application, but methylchloride will not be accepted. Attention is also drawn to any statutory requirements of the country, in which the ship is to be registered.

1.4 Plans and particulars

1.4.1 The following plans and particulars, and any other information which may be specially requested, are to be submitted, in triplicate, for consideration before construction is commenced:

a) Refrigerating plant - detailed specification;

b) Insulation - detailed specification;

c) General arrangement of insulated chambers in elevation and plan. The plans are to be to a scale adequate for the measurement of external surfaces and the deck and bulkhead edges. Dimensions and spacing of frames, beams and stiffeners, and details of other steel works intruding into the insulation and within the chambers, are to be shown. Oil fuel and liquid cargo tanks adjacent to or below the chambers, and whether heating is provided for such tanks, are to be indicated along with the maximum design temperature to be maintained in those tanks, ventilating and air conditioning trunks and ducts passing through chambers are to be shown. The plans are to include a diagram showing the position of the chambers in relation to other parts of the ship if this is not otherwise apparent;

d) Detailed plans showing the thickness and methods of attachment of the insulation and lining on all surfaces including girders, hatch coamings and pillars; details of insulated doors and hatch access, bilge and manhole plugs and their frames. Methods of attachment of brine or direct expansion grids and meat rails are also to be shown;

e) Arrangements of air ducts (including method of cooling spaces within hatch coamings), air coolers, fans and their motors;

f) Air cooler defrosting arrangements;

g) Arrangement of brine grids and method of construction;

h) Arrangement of chamber thermometers and/or temperature sensoring devices;

i) General arrangement of refrigerating machinery;

j) Brine circuit diagram with particulars of piping;

k) Primary refrigerant gas and liquid circuit diagrams and full particulars of all pressure piping;

l) Sectional arrangement of refrigerant compressors;

m) Detailed dimensional plans of :

  - Reciprocating compressor crankshafts, or rotors of screw-type compressors
  - Reciprocating compressor crankcases where exposed to the refrigerant pressure or the casing of screw-type compressors
  - Condensers
  - Evaporators (brine coolers)

- Air coolers
- Oil separators
- Liquid receivers
- Any other pressure vessels.

1.4.2 Where it is proposed to use components such as compressors, condensers, oil separators, etc., that currently have general approval, the type and model number of the component are to be stated. Plans of items that have been so approved need not be re-submitted.

1.4.3 Where refrigerated air circulating fans are electrically driven, plans of the motors are to be submitted in accordance with Pt.4, Ch.8.

1.4.4 Where it is proposed to apply centralized bridge or automatic controls, a description of the scheme and particulars of the spares to be carried are to be submitted.

1.4.5 Any subsequent modifications or additions to particulars, and/or arrangements shown on the approved plans or in the specifications, are also to be submitted for approval.

1.4.6 Where refrigeration is effected by forced air circulation over coolers, the proposed fan output in each chamber will be considered in relation to the heat to be removed, the nature of the cargo, and the service(s) intended.

1.5 Heat balance test

1.5.1 A heat balance test may be required, as prescribed in this Chapter, on a classed installation, or one being considered for reclassification, when extensive repairs or alterations have been carried out, or when the Surveyors consider that an amended temperature notation should be assigned.

1.6 Novel arrangement and design

1.6.1 Where the proposed construction of the refrigerating plant or refrigerated chambers is novel in design or involves the use of unusual materials, special tests may be required, and a suitable class notation may be assigned when IRS considers this necessary.

Section 2

Refrigerating Plant

2.1 Refrigerating unit

2.1.1 A refrigerating unit is considered to comprise a compressor (refrigerating machine), its driving motor and one gas condenser. Where a secondary refrigerant is employed the unit is also to include a brine cooler. It is usual for the compressor and the condenser to be permanently connected to the installation with all necessary piping, fittings and electrical equipment. Alternative arrangements to the above will be given consideration in relation to the number of units in the installation and related factors.

2.1.2 Two or more refrigerating machines driven by a single motor, or having only one condenser or brine cooler, are to be regarded as one unit.

2.1.3 The refrigerating units of a classed installation must be completely independent of any refrigerating machinery associated with air conditioning plant, or any domestic refrigerated installation, or any process plant, unless full details of any proposal have been submitted and approved.

2.2 Requirements regarding refrigeration units

2.2.1 The refrigeration provided is to be sufficient to maintain the temperatures specified in the class notation when operating 24 hours per day with one unit in reserve as stand by. In order to compensate for deterioration of machinery and insulation over the life of the installation, the plant is to be designed to have at least 5 per cent excess capacity over that required for maximum design output for the desired class notation.

2.2.2 The proposals of both machinery and insulating contractors will be evaluated by IRS in determining the theoretical capabilities of the plant to maintain the duty temperatures. IRS will advise the contractors after appraisal of the specification and plans if it is considered that additional refrigeration or insulation effect is required, but the temperature assigned on completion of the heat balance tests will be determined on the actual results of the test.

2.2.3 Where the units are not connected in common to all refrigerated chambers, the plant serving each Section is to comply with 2.2.1.

2.2.4 In the case of installations having a large number of small units arranged to serve individual chambers or groups of chambers, the question of standby capacity will be specially considered.

2.2.5 Where only two refrigerating units are fitted, the working parts are to be interchangeable.

2.2.6 Where a refrigerating plant is provided for sub-cooling the liquid refrigerant of other units, but is not arranged for cooling the cargo chambers independently, it will not be regarded as a unit.

2.2.7 The standby or reserve unit may be considered as an operating unit during the limited cooling down period of a non-precooled fruit cargo.

2.3 Location of refrigerating machinery

2.3.1 Refrigerating machinery is to be located in an efficiently ventilated compartment.

2.3.2 Where ammonia is used as the refrigerant, the machinery compartment is to be isolated by gastight bulkheads and decks from any adjacent accommodation or working spaces and provided with at least two access doors.

2.3.2.1 Ammonia piping is not to pass through accommodation spaces.

2.3.3 Compartments containing ammonia machinery (including process vessels) are to be fitted with:

a) A negative ventilation system independent of ventilation systems serving other ship spaces and having a capacity not less than 30 changes per hour based upon the total volume of the space. Other suitable arrangements which are equally effective, may be considered;

b) A fixed ammonia detector system with alarms inside and outside the compartment;

c) Water screens above all access doors, operable manually from outside the compartment;

d) An independent bilge system;

e) At least two sets of ammonia gas masks with hermetically sealed filters and protective clothing are to be available in a glass door case located immediately outside ammonia machinery rooms.

2.3.4 In case of ammonia plants on fishing vessels under 55 [m] in length or other ammonia plants with a quantity of ammonia not greater than 25 [kgs], the plants may be located in machinery space provided:

The area where the ammonia machinery is installed is served by a hood with negative ventilation system, so as to prevent leakage of ammonia from dissipating into other areas in the space;

A water spray system is provided for the area

Requirements of paras 2.3.2.1, 2.3.3b) and 2.3.3e) are complied with.

2.3.5 Where the machinery compartment is unmanned, arrangements are to be made to raise an alarm if the cooling water ceases to circulate, and to shut down the affected compressor(s).

2.3.6 Machinery using non-toxic and non-flammable refrigerants will not in general, be subject to restriction on location, but proposals to install relatively large plants in other than separate compartments are to conform to statutory requirements and will be given special consideration.

2.4 Prime movers

2.4.1 Where the refrigerating plant is electrically driven, the motors and their control gear are to comply with the requirements of Pt.4, Ch.8. The electrical power is to be available as a source from at least two electrical alternators/ generators, with each alternator/generator being of sufficient capacity to take the entire refrigeration and normal sea load.

2.5 Circulating pumps

2.5.1 At least two separate gas condenser cooling water pumps are to be installed. One of the pumps may be considered as a standby pump and may be used for other purposes, provided that it is of adequate capacity and its use on other services does not interfere with the supply of cooling water to the gas condensers.

2.5.2 Where the primary and/or secondary refrigerants are circulated round the system by pumps, a standby pump(s) capable of operating on all cargo chambers is to be provided.

2.6 Sea connections

2.6.1 Condenser cooling water is to be taken from not less than two sea connections, it being recommended that one of the sea connections be provided on the port and the other on starboard side. Proposals are to be submitted for approval.

2.7 Refrigerating machinery design pressures

2.7.1 The scantlings of various parts of refrigerating plant are to be based on the pressures specified in Table 2.7.1.

Table 2.7.1 : Design pressure of refrigerating plant

Refrigerant	Minimum design pressure (g) in bar	
	HP side of system	LP side of system
R 22	20.6	16.7
R 717	21.2	17.2

2.7.2 If refrigerants other than those specified in Table 2.7.1 are used, the design pressure is subject to approval in each individual case. It may, in general, be assumed to be equal to the vapour saturation pressure of the refrigerant at 55°C and 45°C on the HP and LP sides, respectively.

2.8 Compressors

2.8.1 Compressors are to be of an approved type and are to be equipped with all the accessories and instruments necessary for effective and dependable operation.

2.8.2 Crankcases of compressors having cylinders integral with crankcase are normally to be designed to withstand an internal pressure at least equal to the compressor maximum working pressure. Any crankcase designed for a pressure lower than the compressor discharge maximum pressure, is to be provided with a relief valve set to lift at not more than the designed pressure, and the discharge led to a safe place. Compressor crankcases of large machines where cylinders are separate from the crankcase and which are not exposed to the refrigerant pressure when working, and are isolated when the plant is not in use, may have a lower design pressure according to the setting of the relief valve, but in no case is this to be lower than 2 bar.

2.8.3 In case of rotary displacement compressors, the rotor casing is to be designed for the maximum design pressure for the refrigerant.

2.9 Refrigerant pressure vessels

2.9.1 Welded cylindrical pressure vessels which are of steel construction and exposed to the pressure of refrigerants, are to be constructed in accordance with the requirements of Pt.4, Ch.5, so far as applicable.

2.9.2 Where ammonia is the refrigerant, the vessels are to be constructed to at least Class 2 requirements. Radiographic inspection may, however, not be waived regardless of pressure. The specified minimum tensile strength of steel used for shells and dished ends is not to exceed 430 [N/mm^2].

2.9.3 Where pressure vessel shells are made from steel tubes, these are to be seamless, electric resistance welded or longitudinally submerged arc welded. Forge butt welded and spirally welded tubes are not acceptable.

2.9.4 All pressure vessels with a design temperature below - 40°C and also vessels with a design temperature below 0°C where the pressure/saturation temperature relationship does not apply, are to be manufactured from steels with mechanical properties, including notch toughness, suitable for the thickness and the lowest design temperature. Details of the proposed specifications for these steels are to be submitted for approval.

2.10 Pressure piping

2.10.1 Steel piping for primary refrigerant systems is to comply with the requirements of Pt,4, Ch.2. The tubes are to be seamless, electric resistance or submerged arc welded. Forge butt welded tubes are not acceptable. See also 2.14.

2.10.2 Where the piping is galvanized in lengths and then joined by butt welding, the galvanizing is to be removed in way of pipe ends before welding commences.

2.10.3 Copper piping is to be in accordance with Pt.4, Ch.2 except in the case of small air coolers having finned pipe of sizes not greater than 19 [mm] outside diameter, and fabricated under shop conditions. The finned pipe may have a minimum wall thickness of 0.5 [mm] when used with R 22 refrigerant.

2.11 Oil separators, filters and refrigerant driers

2.11.1 Suitable oil separators with drains are to be provided to the refrigerant lines. If wire gauze is used in the separator, it is to be sufficiently robust and supported to prevent disintegration.

2.11.2 Suitable filters are to be provided in the gas lines to compressors and in the liquid lines to regulators. Wire gauze in filters is to be sufficiently robust and supported to prevent disintegration. A filter may be combined with the required oil separator.

2.11.3 Driers are to be fitted in R22 refrigerant systems, and the arrangement is to be such that a drier can be by-passed, isolated and opened up without interrupting plant operations.

2.12 Safety devices

2.12.1 A pressure relief valve and or safety disc is to be fitted between each compressor and its gas delivery stop valve, the discharge being led to the suction side of the compressor. Where the motive power for the compressor does not exceed 10 [kW], the pressure relief valve and/or safety disc may be omitted.

2.12.2 All pressure vessels or other components of refrigerant systems which could become filled with liquid refrigerant and isolated are to be provided with safety discs and relief valves in series, or other approved arrangements, the discharge being led to a safe place above deck.

2.12.3 Suitable spring-loaded safety valves are to be provided to the cooling liquid side of condensers and the brine side of evaporators, where the pressure from any pump in the circuit could exceed the design pressure of the piping or any component forming part of the cooling systems.

2.13 Access to plant

2.13.1 In general, the arrangements are to be such that all components of the refrigerating machinery can be readily opened up for inspection or overhaul. Space is to be provided for the withdrawal and renewal of the tubes in 'shell and tube' type evaporators (brine coolers) and condensers. Proposals for alternative arrangements are to be submitted for consideration.

2.14 Pressure tests

2.14.1 Before installation

a) Components intended for use with a primary refrigerant are to be subject to strength and leak tests as detailed in Table 2.14.1, where p is in the design pressure as defined in 2.7.

b) The leak test normally requires an air pressure to be applied to the component while under water. Any alternative methods of leak testing will be considered on their merits.

c) Components for use with brine or cooling water are to be hydraulically tested to 2.0p but not less than 3.5 bar.

Table 2.14.1 : Pressure tests

Component	Strength test	Leak test
Pressure vessels	1.5p (hydraulic)	1.0p
Compressors		
Crankcase and cylinders in one casting	1.5p (paraffin or oil)	1.0p
Separate Cylinders	1.5p (paraffin or oil)	1.0p
Crankcase separate from Cylinders	1.2p (paraffin or oil	0.8p
Valves and fittings	2.0p (paraffin or oil)	1.0p
Pressure piping, fabricated headers, air coolers, etc.,	1.5p (hydraulic)	1.0p

2.14.2 After erection on board ship

For pressure piping welded in place, hydraulic or pneumatic strength tests of welds are to be carried out at a test pressure of 1.5p. For pneumatic tests the following precautions are to be observed:

- All pressure vessels connected to the system must have already been strength and leak tested;
- All items such as compressor crankcases, gauges and automatic equipment that may be damaged by the test pressure are to be isolated;
- All spaces containing pipe lines under test are to be clear of personnel during the test, and adequate precautions are to be taken to completely prevent any danger to personnel and minimize risk to property;
- The pressure in the piping is to be observed by a gauge remote from the systems;
- The test pressure is to be built up slowly using an inert gas;
- The test pressure is to be held for at least one hour before being released.

a) After completion of the strength test, a leak test is to be carried out at a pressure equal to the design pressure in the presence of the Surveyor.

2.15 Automation

2.15.1 Where plants are operated by thermostatic refrigerant control, efficient manual controls are also to be provided, and the arrangement is to be such that thermostatic controls can be by-passed and isolated.

2.15.2 As an alternative, duplicate thermostatically operated refrigerant control valves may be fitted, each valve to be capable of the required duty and operable with the other out of action.

2.15.3 Where the system is to operate unattended, it is to conform to the general requirements of Ch.22.

2.16 Other refrigerating plant

2.16.1 Particulars of refrigerating plant using refrigerants other than those listed in this Chapter, are to be submitted for special consideration.

2.17 Cooling appliances in refrigerated chambers

2.17.1 Chambers may be refrigerated by pipe grids on the ceiling and sides or by circulation of air over coolers.

2.17.2 Refrigeration by pipe grids in the chamber is to be effected by the circulation of brine except in the case of installations or chambers of very small capacity when direct expansion of the refrigerant will be considered. The pipe grids in each chamber are to be arranged in not less than two sections, and each section is to be fitted with valves or cocks so that it can be shut off. A single section may be approved for a chamber of small capacity but details must be submitted for approval.

2.17.3 Either brine or direct expansion of the refrigerant may be employed in the coils of air coolers. The coils are to be arranged in not less than two sections, each of which is to be capable of being readily isolated when necessary. Alternatively, at least two independent air coolers should be fitted. A single cooler with one circuit may be approved for a chamber of small capacity, but details must be submitted for approval.

2.17.4 In order to minimise the dehydration of the cargo and the frosting of the cooling appliances in each chamber aboard bulk refrigerated cargo ships, it is recommended that the installation be designed to maintain the required minimum temperature under the maximum difference of not more than 4.5°C between the cooling medium and the chamber.

2.17.5 Steel piping used to convey primary or secondary refrigerants within the refrigerated cargo chambers, or where embedded in insulation, is to be galvanized externally. For brine piping, an alternative method of protecting the piping against corrosion may be approved. Details are to be submitted for approval.

2.17.6 Where the pipe connections are by screwed couplings or by butt welds, the ungalvanized portion of the piping is to be suitably coated and taped after pressure testing to prevent the ingress of water vapour to the ungalvanized pipe and to reduce the incidence of corrosion. The locations of the joints are to be marked on the outside of the insulation.

2.17.7 Brine tanks and piping are not to be galvanized on the brine side. However, if any parts of the brine system have been galvanized, the brine cooling and return tanks, if closed, are to be provided with a ventilating pipe or pipes led to the atmosphere in a location where no damage will arise from the gas discharged, and the ventilating pipes are to be fitted with wire gauze diaphragms which can readily be renewed. Where the brine tanks are not closed, the compartments in which they are situated are to be efficiently ventilated.

2.17.8 Means are to be provided for effectively defrosting air coolers. Air coolers are to be provided with trays of suitable depth arranged to collect all condensate. The trays are to be provided with drains at the bottom so that the whole of the condensate can be drained away when the chambers are in service.

2.17.9 Where circulation of refrigerated air in a chamber is dependent on a single fan and electric motor, access arrangements are to be such that both the fan and the motor can be readily removed for repair or renewal, when the chamber is loaded with refrigerated cargo. Access for servicing only is required where several fans and motors are installed.

2.17.10 The air circulation system is to be arranged for positive air delivery to, or suction from all parts of the chamber, including any space within hatch coamings.

2.18 Heating arrangements for fruit cargoes

2.18.1 Where it is intended to carry fruit cargoes which may be adversely affected by low temperatures into areas where the ambient temperature may be below the carrying temperature, facilities for heating the chambers are to be provided.

2.19 Air refreshing arrangements

2.19.1 Where chambers are intended for the carriage of refrigerated cargoes requiring controlled ventilations, air refreshing appliances are to be provided. The positions of the air inlets are to be carefully selected to minimize the possibility of contaminated air entering the chambers. Each individual chamber is to be provided with its own separate inlet and discharge vent. Each vent is to have a positive airtight valve capable of closing on to a seat. It is recommended that a distance of at least 3 [m] is maintained between inlet and exhaust vents.

2.20 Drying of the refrigerating plant

2.20.1 After tightness testing and before charging with refrigerant and oil, the completed plant is to be dried carefully.

Guidance :

The following procedure is advised:

The plant is to be evacuated until an absolute pressure of maximum 0.007 bar is reached, which is to be held constant until all water is evaporated. The plant is then filled with air until atmospheric pressure, and evacuated again until 0.007 bar. Care must be taken that no part of the plant has a temperature lower than 15°C during evacuation.

2.20.2 Vessels, compressors, etc. are to be dried carefully at their place of manufacture.

2.20.3 After drying, all pipe connections, valves, etc. are to be closed gastight.

2.21 Refrigerating plant on ships not classed with IRS

2.21.1 In the case of the refrigerating installations being constructed under special survey on ships not intended to be classed with IRS, the generator engines and electrical equipment, which supply power to the refrigerating installations, are to be constructed in accordance with requirements of the Classification Society concerned. Such plant is to be examined generally and under working conditions by IRS Surveyors.

Section 3

Cargo Chambers

3.1 Airtightness of chambers

3.1.1 The following Rules are mainly concerned with avoiding infiltration of odours, gases, water vapour and air, which may taint or adversely affect the refrigerated cargo or the insulation, or cause undesirable frosting of cooling equipment.

3.1.2 Each individual chamber is to be of steel construction throughout and hose-tested for tightness. Alternative proposals to test more thoroughly by gas or air under slight pressure will be considered.

3.1.3 Consideration will be given to the construction of divisional bulkheads of materials other than steel, between refrigerated cargo chambers, where the chambers concerned are intended for cargo which will not taint or otherwise adversely affect the cargo in any other chamber; for example, gases given off by fruit of one category may adversely affect fruit of another category by promoting rapid ripening or, alternatively, adverse organic effect.

3.1.4 Hatch closing appliances, access doors, tonnage doors, bilge and manhole plugs forming part of the insulated envelope of independently refrigerated chambers, are to be made air tight. Where hatch covers or plugs are exposed to ambient conditions, they are to be provided with a double seal.

3.1.5 Ventilators, ducts or pipes passing through refrigerated chambers to other compartments are to be made airtight and efficiently insulated. Particular attention is to be given to insulation linings forming surfaces of air ducts. Ventilators to refrigerated spaces, if fitted, are to be provided with airtight closing appliances.

3.1.6 Refrigeration pipes passing through bulkheads or decks of refrigerated cargo chambers are not to be in direct contact with the steel work, and the holes through which they pass are to be true and of suitable finish for effectively sealing by the method intended. It is recommended that holes be trepanned and not burnt out. The airtightness of the bulkheads and decks is to be maintained.

3.1.7 Where cooling pipes pass through watertight plating and bulkheads, the fittings and packing of the glands are to be both fire resisting and watertight. Refrigerating pipelines are to be effectively insulated outside the chambers they serve, except within insulated brine cooler and control rooms.

3.1.8 Insulation lining, bilge limbers and plugs, and chamber and access doors are to be constructed of water-vapour- resisting material, or covered with such material, and where exposed to bilges or external conditions, they are to be sealed.

3.2 Insulation

3.2.1 Steelwork is to be thoroughly cleaned and suitably coated with an approved composition and is to be examined for airtightness of fittings before insulation is applied.

3.2.2 Insulating material approved by IRS is to be used throughout, and the thickness of insulation over all surfaces and the manner in which it is supported is to be in accordance with the approved specifications and plans.

3.2.3 The insulation is to be efficiently packed and, where it is of slab form, the joints are to be butted closely together and staggered. Unavoidable crevices are to be filled with insulating material, but bitumen is not to be used for filling crevices. When it is intended to use a foam 'in-situ' type of insulant, full details of the process are to be submitted for approval before the work commences. The insulants, linings, sealants and paints are to be free from odour likely to cause taint.

3.2.4 Organic foam insulants are to be of self-extinguishing grade and are to be type approved. Certification by an independent authority is a requirement of type approval. For protection from fire, organic foam insulants are acceptable only when fitted behind a metallic lining or its equivalent. Special foams having exceptional fire resisting qualities may be accepted without a lining, provided that they have been approved for this type of application.

3.2.5 Where the insulation is to support fork lift trucks, the strength of the lining and its supports is to be demonstrated. A sample of the insulation 4 [m] x 4 [m] is to be prepared and tested by a fully loaded fork lift truck being driven and maneuvered over the sample to the satisfaction of the Surveyors.

3.2.6 If the cargo to be loaded on to tank top insulation could cause damage to the lining, then additional protection is to be provided in way of the hatch and 0.6 [m] beyond. The protection may either be of a permanent or temporary nature.

3.2.7 Insulation linings and air screens, together with supports, are to be strong enough to withstand the loads imposed by either refrigerated or general cargo.

3.3 Access plugs and panels

3.3.1 Insulated plugs are to be provided in the insulation where required for easy access to the bilges, bilge suction roses, cooler and chamber drains and tank manhole lids. Removable panels are to be provided for access to tank air and sounding pipes and drains.

3.3.2 It is recommended that where the insulation is covered with reinforced asphalt, a number of small insulated inspection plugs be fitted for leak detection.

3.3.3 Successive coatings of an approved oil impervious composition are to be applied to the surface of oil storage tank tops and bulkheads when insulation is to be fitted in way of tank plating. The total thickness of the coating required will depend on the construction of the tank, the composition used and the method of application.

3.3.4 Tank top insulation in way of manholes and bilge hats is to be provided with a liquidtight steel coaming to prevent seepage into insulation.

3.4 Piping in way of refrigerated chambers

3.4.1 Sounding pipes are to be not less than 32 [mm] bore.

3.4.2 All sounding pipes, whether for compartments or tanks, which pass through refrigerated spaces or the insulation thereof, in which the temperatures contemplated are 0°C or below, are to be not less than 65 [mm] bore.

3.4.3 Sounding pipes to oil compartments are not to terminate within refrigerated chambers or in the fan and battery rooms for these chambers, nor are these pipes to terminate in enclosed spaces from which access is provided to refrigerated cargo chambers or their fan and battery rooms.

3.4.4 All pipes, including scupper pipes, air pipes and sounding pipes that pass through chambers, intended for the carriage or storage of refrigerated produce are to be well insulated.

3.4.5 Where the pipes, referred to in 3.4.4 pass through chambers intended for a temperature of 0°C or below, they are also to be insulated from the steel structure, except in positions where the temperature of the structure is mainly controlled by the external temperature and will normally be above freezing point. Pipes passing through a deckplate within the shipside insulation, where the deck is fully insulated below and has an insulation ribband on top, are to be attached to the deckplating. In the case of pipes adjacent to shell plating, metallic contact between the pipes and the shell plating or frames is to be arranged so far as practicable.

3.4.6 The air refreshing pipes to and from refrigerated compartments need not, however be insulated from the steel work.

3.5 Drainage from refrigerated cargo spaces

3.5.1 Provision is to be made for the continuous drainage of the inside of all insulated chambers and cooler trays.

3.5.2 Drains which are led from lower holds and cooler trays situated on the tank top are to be fitted with liquid sealed traps and non-return bilge valves.

3.5.3 Drains from tween deck chambers and from cooler trays which are situated well above the tank top are to be fitted with liquid sealed traps.

3.5.4 Where drains from separate chambers join a common main, the branch pipes are each to be provided with a liquid sealed trap.

3.5.5 The liquid sealed traps are to be of adequate depth and are to have a pressure head of at least 100 [mm] when connected to air ducts and 50 [mm] otherwise and arrangements are to be made for ready access to the traps for cleaning and refilling with brine.

3.5.6 Sluices, scuppers or drain pipes which would permit drainage from compartments outside the insulated chambers into the bilges of the latter, are not to be fitted.

3.5.7 Screwed plugs or other means for blanking off scuppers draining insulated chambers and cooler trays are not to be fitted. If, however, it is especially desired to provide means for temporarily closing these scuppers, they may be fitted with shut off valves controlled from ready accessible positions on a deck above the load water line. An indicator is to be provided to indicate whether the valve is open or shut.

3.6 Airtightness of insulation lining and air ducts

3.6.1 Air ducts and insulation linings are to be so constructed and fitted that moving air is prevented from entering the insulation. Special care is necessary where cooling pipes, air refreshing ducts, fan supports, etc. protrude through the lining.

3.7 Cargo battens

3.7.1 Where the carriage of fruit is intended and provision is made for adequate air circulation through the stow, then cargo battens may be omitted.

3.7.2 Where the carriage of frozen cargo is intended, provision is to be made for the circulation of air between the insulation lining and the frozen cargo. Where cargo battens are used to maintain the air passage, they may be integral with the lining, fastened to the lining, or added as dunnage during cargo loading, to all exposed vertical or near vertical, surfaces of the insulation lining. They are to be arranged to suit the air flow.

They need not be fitted to air screens and cooler casings for the purpose of providing an air passage. Where it is intended to carry refrigerated cargo within the hatch trunk, a full flow of air over the cargo and below the hatch covers is considered essential. The air flow may be promoted by use of air trunking or special battening arrangements.

3.8 Galvanizing of fixtures

3.8.1 All steel bolts, nuts, hangers, brackets and fixtures which support or secure cooling appliances, insulation, meat rails, etc. are to be galvanized.

3.9 Temperature measurement

3.9.1 Thermometers are to be of approved type, number and position in each chamber.

3.9.2 Thermometer tubes with their flanges and covers are to be insulated from the deck plating, and on weather decks they are to be so arranged that water will not run down the tubes when temperatures are being taken.

3.9.3 The inside diameter of thermometer tubes is to be not less than 50 [mm], and the tubes are not to be in contact with cold decks.

3.9.4 Where thermometer tubes pass through compartments other than those which they serve, they are to be efficiently insulated.

3.9.5 The thermometers used in thermometer tubes are to have a suitably slow reaction with respect to temperature change.

3.9.6 When in refrigerated cargo chambers only remote thermometers are fitted, at least two instruments are to be provided for each installation. The sensing elements in each chamber are to be divided between the two instruments in an appropriate manner. One of the instruments may be a data logger. The data logger is to comply with the requirements of 3.9.8.

3.9.7 The accuracy of remote thermometer is to be compatible with the sensitivity of the cargo to temperature variations. If no special requirements are given, the following applies:-

Accuracy of measuring device

Below 0°C	At 0°C and above
± 0.5°C	0.25°C

In the above are included possible errors from resistance variations in cables and instrument reading errors. The combined errors of instrument reading and hysteresis are to be less than 0.1°C.

3.9.8 The scale of the instruments is to cover the whole expected range of chamber air temperatures ± 3°C. The scale deflection for fruit cargo is not to be less than approximately 5 [mm/°C] and for frozen cargo not less than 2.5 [mm/°C]. The temperature reading is to be possible within 0.1°C of both scale instruments and digital panels.

3.9.9 The sensing elements are to be well protected against mechanical damage and moisture. They are to be permanently connected to their instruments, i.e. no plug- in connections are allowed.

3.9.10 Remote thermometers and their installation is to be in accordance with the requirements of Pt.4, Ch.7.

Section 4

Tests

4.1 Thermometers

4.1.1 All thermometers and equipment for the measuring of chamber and air suction and delivery temperatures are to be installed in accordance with the approved plans and the whole installation completed to the satisfaction of the Surveyors.

4.1.2 Each thermometer is to be checked for accuracy by the contractors, and a statement is to be given to the Surveyors giving the readings to the nearest 0.1 of a degree at the freezing point of water. The Surveyors may use their discretion as to whether check tests are necessary. In the case of electric remote reading instruments, a statement of calibration for each instrument indicating the method employed is to be indicated.

4.2 Fan and air circulation systems

4.2.1 Air cooler fans are to be tested by the contractors after the air circulating system has been completed, and a statement of the results for each chamber handed to the Surveyors. The statement is to show the static pressure, the volume of air circulated per minute, the fan speed and the power consumption. The air circulation arrangements in the chambers are to be checked for distribution.

4.3 Refrigeration tests

4.3.1 All the plant is to be tested under working conditions, and when found to be operating satisfactorily, the capability of the installation to perform its maximum duty, as stated in the temperature qualification, is to be determined by the IRS thermal balance test.

4.3.2 The IRS balance test measures the capability of the combined plant and insulated chambers to carry out the duty required by the temperature qualification. It does not separately measure the insulation value or the efficiency of the machinery. Failure of the installation to perform satisfactorily may require the machinery manufacturer and the insulating contractor separately to prove their respective parts of the installation.

4.3.3 The thermal balance test is to be carried out under the supervision of and to the satisfaction of the Surveyors.

4.3.4 The insulated envelope is to be closed up, including air refreshing arrangements and the priming of scuppers. The hatch covers are to be made airtight to the satisfaction of the Surveyors.

4.3.5 During the test, comprehensive logs of machinery working conditions and chamber temperatures are to be made.

4.3.6 External thermometers are to be provided, and the external temperatures are to be logged at frequent intervals during the test.

4.3.7 The electrical energy input to fan and brine pumps is to be measured by wattmeter.

4.3.8 Prior to, or on completion of, the tests, the air coolers are to be defrosted.

4.3.9 If the heat balance test is held at some temperature in chambers above the qualification temperature, then on completion of test, the chambers are to be lowered to the qualification temperature.

4.3.10 The temperature of the chambers should not be reduced more than 1°C below the minimum designed temperature without the express permission of the Owner, the Builder and IRS.

4.3.11 Observations are to be recorded from the beginning of the cooling down to the end of the test. In the early stages, logging may be at intervals of about 4 hours, but external temperatures are to be logged hourly for the final 18 hours of the test, and all other relevant temperatures and pressure, speed and power consumption of compressor and fan motors, power consumption of brine and cooling water pumps, are to be logged hourly for the final 12 hours of the test.

4.3.12 Where an installation is to be completed and tested during a period when extremely low external temperatures are probable and a reasonable difference between the external and internal temperature will not be possible, the case is to be submitted for special consideration.

4.3.13 The air refreshing arrangements when fitted, safety devices (where practicable) and automatic arrangements are to be tested and found satisfactory.

Section 5

Spare Gear

5.1 General

5.1.1 It is recommended that adequate spares, together with the tools necessary for maintenance, or repair, be carried. The spares are to be determined by the Owner according to the design and intended service. The maintenance of the spares is the responsibility of the Owner.

End of Chapter

Chapter 24

Dynamic Positioning Systems

Contents

Section

Section 1

General

1.1 Scope, application

1.1.1 The requirements of this Chapter apply to ships with installed dynamic positioning systems and are in addition to those applicable in other Parts of these Rules.

1.1.2 A ship provided with a dynamic positioning system in accordance with these Rules will be eligible for an appropriate class notation which will be recorded in the Register Book.

1.1.3 Requirements, additional to these Rules may be imposed by the National Authority with whom the ship is registered and/or by the administration within whose territorial jurisdiction it is intended to operate.

1.1.4 These rules specify design criteria, necessary equipment, tests and documentation requirements for dynamic positioning systems to reduce risk to personnel, the vessel, other vessels or structures and the environment while performing operations under dynamic positioning control.

1.1.5 For the purpose of these Rules, the area of operation is the specified allowable position deviation from the desired set point.

1.2 Definitions

1.2.1 **Dynamically positioned vessel** means a vessel which automatically maintains its position and heading (fixed location or predetermined track) by means of thruster force.

1.2.2 **Dynamic positioning system** means the complete installation necessary for dynamically positioning a vessel, comprising of the following sub-systems:

a) Power system
b) Thruster system
c) DP-control system
d) Independent joystick system.

1.2.3 **Position/heading keeping** means maintaining a desired position/heading within the normal excursions of the control systems and environmental conditions.

1.2.4 **Power System** means all components and systems necessary to supply the DP-system with power. The power system includes:

a) Prime movers with necessary auxiliary systems including piping

b) Generators

c) Switchboards

d) Distributing system (cabling and cable routing)

e) Uninterrupted Power Supply (UPS)

f) Power Management System (PMS) or equivalent arrangements, as applicable.

1.2.5 **Thruster System** means all components and systems necessary to supply the DP-system thrust force and direction. The thruster system includes:

a) Thrusters with drive units and necessary auxiliary systems and piping
b) Main propellers and rudders if these are under the control of the DP-system
c) Thruster controls
d) Associated cabling and cable routing

1.2.6 **DP-control system** means all control components and systems, hardware and software necessary to dynamically position the vessel. The DP-control system consists of the following:

a) Computer system
b) Sensor system
c) Display system
d) Operator panels
e) Position reference system
f) Associated cabling and cable routing

1.2.7 **Redundancy** means ability of a component or system to maintain or restore its function, when a single failure has occurred. Redundancy can be achieved for instance by installation of multiple components, systems or alternative means of performing a function.

1.2.8 **Failure** is an occurrence in a component or system causing one or both of the following effects:

- loss of component or system function

- deterioration of functional capability to such an extent that the safety of the vessel, personnel, or environment is significantly reduced.

1.2.9 **Worst case failure** means the identified single failure mode in the DP system resulting in maximum effect on DP capability as identified through FMEA study.

1.2.10 **Reliability** is the ability of a component or system to perform its required function without failure for specified time interval under stated environmental conditions.

1.3 Classification notations: definition and general principles

1.3.1 In addition to the Hull and Machinery class notations, ships complying with the requirements of this Chapter will be eligible to be assigned any of the following class notations:

DP(1) This notation may be assigned when a ship is fitted with automatic controls for position keeping, an independent joystick system back-up and a position reference back-up.

DP(2) This notation may be assigned when a ship is fitted with automatic controls for position keeping with automatic standby controls, an independent joystick system back-up and redundancy in design and equipment as required by these rules.

DP(3) This notation may be assigned when a ship is fitted with automatic controls for position keeping with automatic standby controls, an independent joystick system back-up and redundancy in design and equipment. In addition, physical separation of components is to be provided by locating in different compartments as required by these rules. Full stop of thrusters and subsequent start-up of available thrusters is not considered as an acceptable disruption.

1.4 Design redundancy and failure modes

1.4.1 The worst-case failure modes for the above class notations are to be as follows:

1.4.1.1 For notation DP(1), loss of position may occur in the event of a single fault.

1.4.1.2 For notation DP(2), a loss of position is not to occur in the event of a single fault in any active component or system. Normally, static components will not be considered to fail where adequate protection from damage is demonstrated and properly documented with respect to protection and reliability.

Single failure criteria for DP(2) include:

a) Failure of any active component or system (generators, thrusters, switchboards including the short circuit of switchboard bus bars, remote controlled valves, coolers, filters etc.)

b) Fault in any normally static component (cables, pipes, manual valves etc) which is not properly documented with respect to protection

c) A single inadvertent act if such an act is reasonably probable

d) systematic failures or faults that can be hidden until a new fault appears

e) automatic interventions caused by external events, when found relevant (e.g. automatic action upon detection of gas).

1.4.1.3 For notation DP(3), loss of position is not to occur after any of the following failures in addition to 1.4.1.2 above:

a) Fault in any normally static component in the system

b) Failure to all components in any watertight compartment, from fire or flooding

c) Failure to all components in any fire sub-division, from fire or flooding

1.4.2 Based on the failure definitions in 1.4.1, the worst-case failure is to be determined with the help of F.M.E.A. and used as the criteria for consequence analysis.

Requirement for failures to be considered are summarized in Table No. 1.4.2:

Table 1.4.2 : Failures to be considered for various class notations

Notation	Position keeping criterion	FMEA required	Failures to be considered				
			Static components	Active components	Inadvertent acts	Hidden failure	Failure of all components in a watertight compartment / fire subdivision due to fire or flooding
DP1	Loss of position may occur after single failure	-	-	-	-	-	-
DP2	Loss of position is not to occur after single failure	Yes	Yes 1	Yes	Yes	Yes	No
DP3	Loss of position not to occur after single failure including fire / flooding in one compartment	Yes	Yes	Yes	Yes	Yes	Yes
Note 1 : Not required if the static component (cables, pipes, manual vales etc.) is properly documented with respect to protection.							

The objective of FMEA is to provide a comprehensive, systematic and documented analysis to establish the significant failure modes with regards to position keeping and demonstrate that the vessel maintains position in the event of single failure.

Essentially the FMEA is to

- Breakdown the DP system into functional blocks and function of each block is to be described
- Identify potential failure modes and their causes
- Evaluate effect on the system for each failure mode
- Identify measures for eliminating and reducing the associated risks
- Identify the trials required to prove the conclusion
- Provide information to operators on system limitations and capabilities.

1.4.3 In order to meet the failure criteria, redundancy of components will normally be necessary as follows:

a) For class notation DP(2), redundancy of all active components;

b) For class notation DP(3), redundancy of all components and physical separation of the components by A-60 class fire divisions, watertight below the damage control deck. (maximum possible physical separation of sensors above deck),

1.4.4 For class notation DP(3), non-redundant connections between otherwise redundant and separated systems may be accepted provided that it gives clear safety advantages and their reliability can be demonstrated and documented to the satisfaction of IRS. Such connections are to be kept to the absolute minimum and made to fail to the safest condition. Failure in one system is not to transfer to the other redundant system.

1.4.5 Redundant components and systems are to be immediately available. The transfer to redundant component or system is to be automatic as far as possible, and the operator intervention is to be kept to a minimum. The transfer should be smooth and within acceptable limitations of the operation.

1.4.6 For class notation DP(3), cables for redundant equipment or systems and are not to be routed together through the same compartments. Where this is unavoidable, such cables may be run together in cable ducts of A-60 class. Cable connection boxes are not allowed in such ducts. On open deck, cables in separate pipes that are separately routed may be accepted. Suitable means are to be provided to keep the ambient temperature inside of an A-60 cable duct within maximum temperature for the cables, when necessary, taking into account the temperature rise of cables under full power.

1.4.7 For class notation DP(3), redundant piping systems (e.g. fuel oil, lubrication oil, cooling water, hydraulic oil, pneumatic etc.) are not to be routed together through the same compartments. Where this is unavoidable, such pipes may be run together in ducts of A-60 class.

Redundant fuel oil supply systems are to be arranged with separate dedicated service tanks.

1.4.8 The requirements for various class notations in these rules are considered to satisfy the equipment classes in IMO guidelines for vessels with dynamic positioning systems (MSC Circ.645) as noted in Table 1.4.8.

Table 1.4.8 : Correlation with IMO equipment classes

IRS Class notation	IMO equipment class
DP(1)	Equipment class 1
DP(2)	Equipment class 2
DP(3)	Equipment class 3

1.4.9 The basic requirements for systems and equipment to be provided for various class notations are summarized in Table 1.4.9. The detailed requirements for thrusters, power systems and DP-control systems are given in sections 2, 3 and 4 of this chapter.

1.5 Information and plans required to be submitted

1.5.1 Proposals for redundancy and segregation provided in the machinery, electrical installations and control systems are to be submitted. These proposals are to take account of the possible loss of performance capability should a component fail or in the event of fire or flooding.

Table 1.4.9 : Requirements for various class notations

Item	**Requirement for class notation:**		
	DP(1)	**DP(2)**	**DP(3)**
1. Thrusters:			
a) Arrangement	No redundancy	Redundant	Redundant and in separate compartments
b) manual single lever control of individual thruster	yes	yes	yes
2. Power systems:			
a) Electrical power generation and distribution systems	No redundancy	Redundancy in design	Redundancy in design and physical separation by A-60 divisions.
b) Bus tie breakers	no	yes	yes
c) Main Switchboard (MSB)	yes	yes	yes
d) Power Management System (PMS) or equivalent arrangements	no	yes	yes
3. DP control system: [1])			
a) Computer systems for automatic control	1	2	2 plus one additional system in back-up control station
b) Consequence analysis	no	yes	yes
c) Independent common joystick control with manual/automatic heading control	yes	yes	yes
4. Position reference systems [2)]	2	3	3, of which one system is in back-up control station
5. External sensors:			
a) Wind	1	2	2, of which one is connected to back-up control station
b) Gyro Compass	1	3	3, of which one in back-up control station
c) Vertical reference system	1	3	3, of which one in back-up control station
6. UPS	1	2	2 plus one in back-up control station
7. Back-up control station	no	no	yes
8. Printer	yes	yes	yes

Notes

1) **Operational mode** is the manner of control under which the DP-system may be operated, e.g.:

— automatic mode (automatic position and heading control)
— joystick mode (manual position control with selectable automatic or manual heading control)
— manual mode (individual control of thrust, azimuth, start/stop of each thruster)
— auto track mode (considered as a variant of automatic position control, with programmed movement of reference point).

2) **Position/heading reference system** consists of all hardware, software and sensors that supply information and or corrections necessary to give position/heading reference, including power supply.

1.5.2 Electrical load calculation for dynamic positioning operation is to be submitted for approval. For class notations DP(2) and DP(3), the load calculations are to consider the situation after the worst-case failure. (See 1.3.2).

1.5.3 Plans of the following together with particulars of ratings in accordance with the relevant Parts of the Rules are to be submitted for:

a) Prime movers, gearing, shafting, propellers and thrust units;

b) Machinery piping systems;

c) Electrical installations;

d) Pressure vessels for use with dynamic positioning system; and

e) For DP(3) notation the following are to be submitted in addition:

   i) Routing of pipes and cables for redundant systems

   ii) Location of redundant machinery and electrical equipment.

1.5.4 Plans of control, alarm and safety systems including the following are to be submitted:

a) Functional block diagrams of the control system(s) including the independent joystick system;

b) Functional block diagrams of the position reference systems and the environmental sensors;

c) Details of the electrical supply to the control system(s) the position reference system(s) and the environmental sensors;

d) Details of the monitoring functions of the controllers, sensors and reference system together with a description of the monitoring functions;

e) List of equipment with identification of the manufacturer, type and model;

f) Details of the overall alarm system linking the centralized control station, subsidiary control stations, relevant machinery spaces and operating areas;

g) Details of the control stations, e.g. control panels and consoles, including the location of the control stations;

h) Test schedules which are to include the methods of testing and the test facilities provided; and

i) Failure Modes and Effects Analysis (F.M.E.A.) in the case of notations DP(2) and DP(3).

1.5.5 Operation manuals, including details of the dynamic positioning system operation, installation of equipment, maintenance and fault finding procedures together with a section on the procedure to be adopted in emergency are to be submitted. A copy of the manual is to be placed on board the ship.

1.5.6 Performance capability evaluation report of the DP system for position keeping ability in the specified operating environmental conditions is to be submitted. This is to include a diagrammatic representation (DP capability Plot) of the limiting wind speeds and direction for effective DP operation, considering wave and current loads also acting simultaneously. A copy of the performance capability evaluation report is to be placed onboard the ship.

1.6 Performance capability of the DP system

1.6.1 The performance capability of the dynamic positioning system to provide sufficient thruster forces and moments for maintaining position and heading in specified environmental conditions, is to be evaluated. The wind, wave and current conditions in a specified area are to be considered for this purpose.

1.6.2 A performance capability rating may be assigned by IRS for the DP system, if requested. The rating would indicate the percentage of time that environmental forces in a specified area may be withstood by the system.

1.6.3 The following parameters are considered in the evaluation of the performance capability rating:

a) Thruster forces
b) Wind loads on the ship
c) Wave drift loads on the ship
d) Current loads on the ship.

Section 2

Thruster System

2.1 General

2.1.1 Thrusters are to be manufactured, installed and tested in accordance with the relevant requirements of Pt.4 together with the requirements of this Chapter.

2.1.2 Where propellers for main propulsion are part of the DP system, they are to satisfy the requirements of thrusters given in this chapter. Steering gears controlled by DP system are to be designed for continuous operation.

2.2 Thruster system

2.2.1 The thruster system is to be designed to provide adequate thrust in longitudinal and lateral directions, and yawing moment for heading control.

2.2.2 The response and repeatability of thrusters to changes in propeller pitch or propeller speed/direction of rotation are to be suitable for maintaining the area of operation and the heading deviation specified.

2.2.3 For class notations DP(2) and DP(3), in the event of failure of the most effective thruster the ship is to be capable of maintaining its predetermined area of operation and desired heading in the environmental conditions for which the ship is designed and/or classed.

2.2.4 Thruster installations are to be designed to minimize potential interference with other thrusters, sensors, hull or other surfaces which could be encountered in the service for which the ship is intended.

2.2.5 The values of thruster force used in the consequence analysis (see 4.2.13) is to be corrected for any unavoidable interference between thrusters and other effects which would reduce the effective force.

2.2.6 Thruster intakes are to be located at sufficient depth to reduce the possibility of ingesting floating debris and vortex formation.

2.2.7 Steerable thrusters and thrusters having variable pitch propellers are to be provided with independent supplies of motive power to the pitch and direction actuating mechanisms.

2.2.8 Each thruster unit is to be provided with a high power alarm. The setting of this alarm is to be adjustable and below the maximum thruster output.

2.2.9 Failure of thruster system including pitch, azimuth or speed control is not to result in rotation or uncontrolled full pitch and speed of the thruster.

2.2.10 The thrust unit housing is to be tested at a hydraulic pressure of not less than 1.5 times the maximum service immersion head of water or 1.5 bar, whichever is the greater.

2.3 Emergency stop

2.3.1 It is to be possible to stop each thruster individually from the main DP-control centre by means independent of the positioning and thruster control systems. This emergency stop is to be arranged with separate cables for each thruster.

Section 3

Power Systems

3.1 General

3.1.1 The power systems are to be designed, constructed and installed in accordance with the relevant requirements of Pt.4, together with the requirements of this Chapter.

3.1.2 For class notation DP (2), the power system is to be divisible into two or more systems such that in the event of failure of one system, at least one other system will remain in operation. The power system may be run as one system during operation, but should be arranged by bus tie breakers to separate automatically upon failures which could be transferred from one system to another, including overloading and short-circuits.

3.1.3 For class notation DP(3), the power system is to be divisible into two or more systems such that in the event of failure of one system, at least one other system will remain in operation. The divided power systems are to be located in different spaces separated by A-60 class division. Where the power systems are located below the damage control deck, the separation is also to be watertight. The bus tie breakers are to be open during operations unless equivalent integrity of power operation can be accepted according to 1.3.5.

3.1.4 Means are to be provided in order to prevent overloading of the power plant, e.g. by use of interlocks, thrust limitations or other means. Means are also to be provided to prevent reactive overload.

3.1.5 Generally no restrictions are to be put on the starting intervals of electrical machines. If required, the arrangement is subject to approval in each case.

3.2 Generators

3.2.1 For class notations DP(1), the total generating capacity of the power system is to be not less than the maximum dynamic positioning load together with the maximum auxiliary load. This may be achieved by parallel operation of two or more generating sets provided the requirements of Pt.4 are complied with.

3.2.2 When the electrical power requirements are supplied by one generator set, on loss of power there is to be provision for automatic starting and connection to the switchboard of a standby set and automatic restarting of essential auxiliary services.

3.2.3 Indication of absorbed electrical power and available on-line generating capacity is to be provided at the main dynamic positioning control station. An alarm is to be initiated at the dynamic positioning control station(s) when the total electrical load of all operating thruster units exceeds a preset percentage of the running generator(s) capacity. This alarm is to be adjustable between 50 and 100 per cent of the full load capacity having regard to the number of electrical generators in service.

For class notations DP(2) and DP(3), in operating conditions where all the generator sets are not being utilized, provision is to be made for automatic starting, synchronization and load sharing of a non-running generator before the load reaches the alarm level required above.

3.2.4 Means are to be provided to prevent starting of thruster motors until sufficient generating capacity is available.

3.2.5 For class notations DP(2) and DP(3), the power available for position keeping is to be sufficient to maintain the vessel in position after the worst-case failure according to 1.3.2.

3.3 Distribution arrangements

3.3.1 Thruster auxiliaries, control computers, reference systems and environmental sensors are to be served by individual circuits. Services that are duplicated are to be separated throughout their length as widely as is practical and without the use of common feeders, transformers, converters, protective devices or control circuits.

3.4 Control system power supply

3.4.1 An uninterrupted power supply (UPS) is to be provided for each DP control and measuring system. UPS battery capacity is to be sufficient to provide output power at maximum load for 30 minutes operation following mains supply failure. The power supply for the independent joystick system is to be independent of the DP-control system UPS.

3.5 Auxiliary supplies

3.5.1 Where the auxiliary services and dynamic positioning thrusters are supplied from a common source:

The voltage regulation and current sharing requirements defined in Pt.4 are to be maintained over the full range of power factors that may occur in service.

Section 4

DP - Control System

4.1 General

4.1.1 The DP control system is to be designed, constructed and installed in accordance with the relevant requirements of Pt.4 together with the relevant requirements of this Chapter.

4.1.2 The control system for dynamic positioning operation is to be stable throughout its operational range and is to meet the specified performance and accuracy criteria.

4.2 System arrangement and functions

4.2.1 In general, the DP control system is to be arranged in a designated DP control station where the operator has a good view of the vessel's exterior limits and the surrounding area.

4.2.2 The DP control station should display information from the power system, thruster system and the DP control system to ensure that these systems are functioning correctly. Information necessary to operate the DP system safely is to be visible at all times.

4.2.3 Indication of the following is to be provided at each station from which it is possible to control the dynamic positioning system, as applicable:

a) Variation in the heading and location of the vessel relative to the desired reference point or course;

b) Vectorial thrust output, individual and total;

c) Operational status of position reference systems and environmental sensors;

d) Environmental conditions, e.g. wind strength and direction; and

e) Availability status of standby thruster units.

4.2.4 Display systems and the DP control station in particular, are to be based on sound ergonomic principles. The system is to provide for easy selection of the control mode, i.e. manual, common joystick or computer control of thrusters and the active mode is to be clearly displayed. Where applicable, feedback signals are to be displayed, not only the initial command. Indicators and controls are to be arranged in logical groups, and are to be co-ordinated with the geometry of the vessel, when this is relevant.

4.2.5 At least one computer system for automatic control is to be provided for class notation DP(1).

4.2.6 The area of operation is to be adjustable, but should not exceed the specified limits which are to be based on a percentage of water depth, or if applicable a defined absolute surface movement. Arrangements are to be provided to fix and identify the set point for the area of operation. It is to be possible to individually enter new position and heading set points in automatic control mode.

4.2.7 Alarms and warnings for failures in systems interfaced to and/or controlled by the DP-control system are to be audible and visual. A permanent record of their occurrence and of status changes are to be provided together with any necessary explanations.

4.2.8 The DP control system should prevent failures being transferred from one system to another. The redundant components are to be so arranged that a failure of one component is to be isolated and the other component activated. When combining position reference systems and/or sensors in one unit where more than one function or system can be lost upon one common failure, the consequence to the total system upon such a failure is not to exceed the loss if non-combined installation was adopted.

4.2.9 Manual control of the thrusters is to be possible individually and by a common joystick independent of the DP-control system. Automatic heading control is to be available along with manual joystick control.
Any failure causing operator loss of control of the thrusters in the independent joystick control system shall freeze the thrust commands or set the thrust commands to zero. If the failure affects only a limited number of thrusters, the command to these affected thrusters may be set to zero, while keeping the other unaffected thrusters in joystick control.

4.2.10 For class notation DP(2), the DP control system is to consist of at least two independent computer systems. Common facilities such as self-checking routines, data transfer arrangements and plant interfaces are not to be capable of causing failure of both/ all systems.

4.2.11 Redundant computer systems are to be arranged with automatic transfer of control after a detected failure in one of the computer systems. The automatic transfer of control from one computer system to another is to be smooth and within the acceptable limits of the operation. It is not to be possible to automatically or manually select a controller which is not ready to assume command as the active controller.

4.2.12 For class notation DP(3), in addition to the requirements in 4.2.10 above, a back-up control system is to be arranged in a room separated by A-60 class division from the main DP control station. During DP operation, this back-up control system is to be continuously updated by input from the sensors, position reference system, thruster feedback etc, and be ready to take over control. The switch-over of control to the back-up computer is to be manual, situated at the back-up computer and not affected by the failure of the main DP-control system. A backup controller status is to be updated at main controller at regular intervals. An alarm is to be initiated if the back up control system fails or is not ready to take control. The back-up DP-control centre is to be arranged with similar view to the vessel's exterior limits and the surrounding area as the main DP-control station.

4.2.13 For class notations DP(2) and DP(3), the DP control system is to include a software function, known as 'consequence analysis', which continuously verifies that the vessel will remain in position even if the worst case failure occurs. This analysis is to verify that the thrusters remaining in operation after the worst-case failure can generate the same resultant thruster force and moment as required before the failure. An alarm is to be provided if the occurrence of a worst-case failure is expected to lead to a loss of position due to insufficient thrust for the prevailing environmental conditions. For operations, which will take a long time to safely terminate, the consequence analysis is to include a function to verify the adequacy of thrust and power remaining after worst-case failure based on manual input of weather trend.

4.2.14 When stopped, either by automatic or manual means, the position control system shall set the thrust commands to zero.

4.2.15 Loss of one or multiple position reference system inputs and/or one or multiple sensor inputs shall not lead to significant change in thrust output.

4.2.16 Upon recovery of position and heading reference input the DP-control system is not to automatically apply the last position or heading set point (set points before loss of input) when this is significantly different from the actual vessel position and/or heading. If any other set point than the actual vessel position and/or heading is applied then it is to be operator chosen.

4.3 Position reference systems and environmental sensors

4.3.1 Position reference systems and environmental sensors are to be provided to ensure that the specified area of operation and heading deviation can be effectively maintained. Sensors are to provide new data with a refresh rate and accuracy suitable for the intended DP operations.

4.3.2 Position reference systems are to incorporate suitable position measurement techniques which may be by means of acoustic devices, radio, radar, inertial navigation, satellite navigation, taut wire or other acceptable means depending on the service conditions for which the ship is intended.

4.3.3 For class notation DP(1), at least two position reference systems are to be provided, each using a different measurement technique. Special consideration may be given to cases where the use of two different measuring techniques would not be practicable during DP operation. In such cases, alternative arrangements may be accepted (for e.g. two DGPS systems).

4.3.4 For class notations DP(2) and DP(3), at least three position reference systems incorporating at least two different measurement techniques are to be provided and simultaneously available to the DP-control system during operation. The position reference systems are to be arranged so that a failure in one system will not render the other systems inoperative.

4.3.5 For class notation DP (3), at least one of the position reference systems is to be connected directly to the back-up control system and separated by A-60 class division from the other position reference systems.

4.3.6 Gyrocompass(es), or equivalent means are to be provided to measure the relative heading of the ship.

4.3.7 Vertical reference sensor(s) are to be provided, if applicable, to measure the pitch and roll of the ship.

4.3.8 Means are to be provided to ascertain the wind speed and direction acting on the ship.

4.3.9 For class notation DP(2) or DP(3), at least three sensors each are to be provided for measurement of parameters required by 4.3.6 and 4.3.7 and at least two sensors are to be provided for 4.3.8 above. In the event of a failure, of a reference or environmental sensor the control systems are to continue operating on signals from the remaining sensors without manual intervention.

4.3.10 For class notation DP(3), one of each type of sensors is to be connected directly to the back-up control system and separated by A-60 class division from the other sensors.

4.3.11 Suitable processing and comparative techniques are to be provided to validate the control system inputs from position and other sensors, to ensure the optimum performance of the dynamic positioning system. Abnormal signal errors revealed by the validity checks are to operate alarms. When several systems are combined to provide a mean reference, the mean value used is to not change abruptly by one system being selected or deselected.

4.3.12 The accuracy of the position reference data is generally to be within the following values as a guidance :

- a radius of 2% of water depth for bottom-based systems

- within a radius of 3 [m] for surface-based systems.

4.4 Alarms

4.4.1 The alarms to be presented in the DP-control centre are normally to be limited to functions relevant to DP operation. Alarms are to be provided for the following fault conditions of the control system/ sensors:

a) Control computer system fault;

b) Automatic changeover to a standby control computer system;

c) Deviation from the predetermined area of operation of the ship;

d) Deviation from the predetermined heading limits of the ship;

e) Position reference system fault (for each reference system);

f) Gyrocompass fault;

g) Vertical reference sensor fault;

h) Wind sensor fault;

i) Taut wire excursion limit;

j) Automatic changeover to a standby position reference system or environmental sensor;

k) Failure in the independent joystick control system;

l) Loss of charger input power and UPS on bypass power;

m) Limit alarms are to be provided for systems, which have defined range limits;

n) For DP(2) and DP(3), if the consequence analysis is not completed within 2 minutes then an alarm is to be initiated; and

o) Any failure of a standby position control system or positioning reference system selected is also to initiate an alarm.

4.4.2 A manually initiated emergency alarm, clearly distinguishable from all other alarms associated with the dynamic positioning system is to be provided at the dynamic positioning control station to warn all relevant personnel in the event of a total loss of dynamic positioning capability. In this respect consideration should be given to additional alarms being provided at locations such as the master's accommodation and operational control stations.

4.5 Internal Communication

A two-way voice communication facility is to be provided between the DP-system control centre and the navigation bridge, ECR and relevant operation control centres.
The two-way voice communication system is to be supplied by a battery or an uninterruptible power supply as a stand-by power supply sufficient to operate the system for at least 30 minutes.

Section 5

Tests and Trials

5.1 General

5.1.1 Before a new installation (or any alteration or addition to an existing installation) is put into service, trials are to be carried out. These trials are in addition to any acceptance tests which may have been carried out at the manufacturers' works and are to be based on the approved test schedules list as required by 1.5.4.

5.1.2 Functional tests of control and alarm systems of each thruster is to be carried out. All sensors and reference systems are to be tested for satisfactory performance as part of the DP system.

5.1.3 The suitability of the dynamic positioning system is to be demonstrated during sea trials, observing the following:

a) Response of the system to simulated failures of major items of control and mechanical equipment, including loss of electrical power; to try out switching modes, back-up systems and alarm systems.
   In case redundancy is based upon change-over of a single stern thruster as described in 1.3.1, then the functionality of the change over mechanism and availability of the thruster after single failure is to be demonstrated at sea-trials.

b) Response of the system under a set of predetermined maneuvers for changing

   - Location of area of operation;

   - Heading of the ship; and

Change of command between the automatic DP-control system, independent joystick system and the individual thruster lever systems are to be demonstrated.

c) Continuous operation of the system over a period of four to six hours, including continuous operation of at least 2 hours during weather conditions such that an average load level on the thrusters of 50% or more is achieved.

5.1.4 All functions of the independent joystick control system are to be tested.

5.1.5 For class notations DP(2) and DP(3), selected tests within each system analysed in the FMEA are to be carried out to verify the conclusions of the FMEA.

5.1.6 Two copies of the dynamic positioning system test schedules, as required by 1.5.4, signed by the Surveyor and Builder are to be provided on completion of the survey. One copy is to be placed on board the vessel.

5.1.7 Records and data regarding the performance capability of the dynamic positioning system are to be maintained on board the ship and are to be made available at the time of the Annual Survey.

5.1.8 During sea trials the offset inputs for each position reference system and relevant sensors in the DP control system are to be verified and demonstrated to the attending surveyor by setting out the offsets on drawings. It is to be verified that these fit with the actual placing of the equipment.

5.1.9 Emergency stop function is to be demonstrated.

5.1.10 For steering gears included under DP control a test is to be carried out verifying that maximum design temperature of actuator and all other steering gear components is not exceeded when the rudder is continuously put over between maximum limits on either side set by the DP-control system, until temperature is stabilized.

In this respect, the ambient conditions specified in Pt.4, Ch.1, 1.7 will be considered. The actual ambient conditions and temperature rise of components are to be noted during trials for evaluation.

5.1.11 The capacity of the UPS battery is to be tested during trials.

End of Chapter

Chapter 25

Fire Fighting Ships

Contents

Section

Section 1

General

1.1 Application

1.1.1 The requirements of this Chapter apply to ships intended for fire fighting operations and are additional to those applicable in Pt.1 to 4 of the Rules.

1.1.2 A ship provided with fire protection and fire fighting equipment in accordance with these Rules will be eligible for an appropriate class notation, as given in 1.2, and which will be recorded in the Register Book.

1.1.3 Requirements additional to these Rules may be imposed by the National Authority with whom the ship is registered and/or by the Administration within whose territorial jurisdiction the fire fighting ship is intended to operate.

1.2 Classification and class notations

1.2.1 Vessels complying with the requirements of this Chapter may be assigned class notations as under :

- "Agni 1 (total monitor discharge capacity in brackets)";
- "Agni 2 (total monitor discharge capacity in brackets)"; and
- "Agni 3 (total monitor discharge capacity in brackets)".

1.2.2 The notation "Agni 1" implies that the vessel has been built for early stage fire fighting and rescue operations close to the structure on fire including means for self protection of the vessel.

1.2.3 The notation "Agni 2 or 3" implies that the vessel has been built for continuous fighting of large fires and for cooling of the structures on fire.

For the notation "Agni 3", a larger water pumping capacity and a more comprehensive fire fighting equipment is required than for the notation "Agni 2".

1.2.4 If a vessel fitted with fire fighting systems and equipment in accordance with the notation "Agni 2 or 3", also has a system for self protection in accordance with the notation "Agni 1", the combined class notation "Agni 1 and 2" or "Agni 1 and 3" may be assigned.

1.3 Scope of classification

1.3.1 The following additional matters are covered by classification :

- The vessel's fire fighting capability;
- The vessel's stability and its ability to keep its position when the fire fighting monitors are in operation; and
- The vessel's ability of self-protection against external fires in case of vessels with the notation "Agni 1".

1.4 Assumptions

1.4.1 The classification of the vessel is based upon the following assumptions :

- the operation of the vessel during fire fighting will be in accordance with the approved operating manual;

- the vessel will carry a sufficient quantity of fuel oil for continuous fire fighting operation with all the fixed water monitors in use for a period not less than :

  - 24 hours for the notation "Agni 1"

  - 96 hours for the notations "Agni 2 or 3";

- foam-forming liquid for at least 30 minutes continuous foam production for the fixed foam monitors is stored on vessels with notation "Agni 3";

- foam-forming liquid for at least 30 minutes continuous foam production by the mobile generator is stored on board in suitable containers on vessels with notation "Agni 2 or 3"; and

- crew operating the fire fighting systems and equipment has been trained in such operations and in the use of air breathing apparatus, and that the skill of the crew is maintained by exercises.

1.5 Submission of plans

1.5.1 The following plans and information are to be submitted:

- A general arrangement showing the disposition of all fire fighting equipment required by this Chapter;

- Manual for the operation of the fire fighting installation and maneuvering of the vessel during fire fighting;

- Details of major items of fire fighting equipment such as pumps and monitors, including their capacity, range and trajectory of delivery;

- A general arrangement plan showing the disposition of the fire divisions and their class;

- Detailed plans of the fire divisions and, where applicable, copies of the certificates of approval for the insulating materials proposed;

- A plan of the construction of the fire doors;

- Plans showing the layout and capacity of the water spray system;

- A plan of the seating arrangements for the water monitors;

- Particulars of the means of keeping the ship in position during fire fighting operations;

- A plan showing the fire pumps, the fire water main, the hydrants, hoses and hose nozzles and the monitors together with particulars of their delivery capability;

- Details of the foam generating system;

- Calculations showing the point of balance between the reaction forces from the water monitors and the forces from the vessel's propulsion machinery and its side thrusters;

- Calculations proving satisfactory stability of the vessel when all monitors are in operation at full capacity in the most adverse direction for stability;

- Report on inclining test determining the centre of gravity and the light weight of the completed vessel;

- Details of the fireman's outfits provided; and

- Plans of any other fire fighting systems provided.

1.6 Operation manual

1.6.1 The following information is to be included in an approved operation manual available on board :

- Detailed description of each fire fighting system;
- Instructions for use, testing and maintenance of the fire fighting installations and the equipment; and
- Instructions for operation of the vessel during fire fighting.

1.7 Items to be manufactured under survey

1.7.1 The following items are to be manufactured under the survey of IRS:

- Fire fighting pumps and their prime movers
- Water / foam monitors
- Compressors for breathing apparatus
- Pipes / valves
- Spray nozzles for self-protection.

1.7.2 The extent of survey and testing is to be in accordance with Pt.4, Ch.2, Sec.1.9 for pipes and valves and as per Pt.4, Ch.1, Sec.1.3 for remaining items.

Section 2

Construction

2.1 Hull

2.1.1 The structure of the ship is to be strengthened as necessary to withstand the forces imposed by the fire-extinguishing systems when operating at their maximum capacity.

2.2 Sea suctions

2.2.1 The seawater suctions of the fire pumps are to be arranged as low as practicable in the ship's structure to avoid icing or the ingress of oil from the surface of the sea.

2.2.2 All sea chests are to be provided with a low pressure steam or compressed air connection for clearing purposes.

2.2.3 Seawater suctions for fire fighting pumps are not to be used for any other purpose. Seawater suction valve, the discharge valve and the pump prime mover are to be operable from the same position. Valves with nominal diameter exceeding 450 [mm] are to both manually operated and power actuated.

2.3 Stability

2.3.1 Each ship is to comply with the draught and stability requirements of the National Authority and is to have on board sufficient stability data to enable the ship to be properly loaded and handled. This data is to take full account of the effect of the monitors when they are operating at their maximum output in all possible directions of use.

2.4 Maneuverability

2.4.1 Arrangements are to be provided to enable the ship to maintain position so that the monitors may be effectively deployed.

2.4.2 Side thruster(s) and main propellers are to be able to keep the vessel at a standstill in calm waters at all combinations of capacity and direction of throw of the water monitors, and the most unfavourable combination is not to require more than 80 per cent of the available propulsion force in any direction.

2.4.3 If the system design is such that, in any operating combination, it will be possible to overload the power supply, a power management system is to be arranged. The system is to include alarm at 80 per cent of available power and automatic action at 100 per cent available power.

2.5 Floodlights

2.5.1 As an aid for operations in darkness at least two adjustable floodlights are to be fitted on board. The floodlights are to be capable of illuminating areas at a distance of 250 [m] in clear air. The floodlights are to be of high pressure sodium vapour type or equivalent.

2.6 Bunkering

2.6.1 The Owner should ensure that any fuel which may be required while the ship is operating on station can be safely received on board.

2.7 Self-protection of the vessel (class notation Agni 1)

2.7.1 The vessel to be protected by a permanently installed water-spraying system.

2.7.2 The fixed water-spraying system is to provide protection for all outside vertical areas of hull, superstructures and deckhouses including foundations for water monitors and other equipment.

2.7.3 The arrangement for the water-spraying system are to be such that necessary visibility from the wheelhouse and the control station for remote control of the fire fighting water monitors can be maintained during the water spraying.

2.7.4 The pipelines and nozzles are to be so arranged and protected that they will not be exposed to damage during the operations for which the vessel is intended.

2.7.5 The fixed water-spraying system is to have a capacity not less than 10 litres per min. per [m^2] of the areas to be protected. For areas internally insulated to class A-60, however, a capacity of 5 litres per min. per [m^2] may be accepted.

2.7.6 The pumping capacity for the fixed water-spraying system is to be sufficient to deliver water at the required pressure for simultaneous operation of all nozzles in the total system. The pumps for the fire fighting water monitors may also serve the spraying system, provided the pump capacity is increased by the capacity required for the water-spraying system. A connection with shut-off valve is then to be fitted between the fire main for the monitors and the main pipeline for the water spraying system.

2.7.7 All pipes for the fixed water-spraying systems are to be protected against corrosion externally and internally by hot galvanizing or equivalent. Drainage plugs are to be fitted to avoid damages by freezing water.

2.7.8 The spray nozzles are to be able to give an effective and even distribution of water spray over the areas to be protected.

2.8 Self-protection of the vessel (class notations Agni 2 and 3)

2.8.1 In ships which are not provided with a water spray system as described in 2.7 all windows and port lights are to be provided with efficient deadlights or external steel shutters, except in the wheelhouse.

2.8.2 Ships which are intended to operate in close proximity to a large fire will require protection from the heat radiated from the fire. Such protection may be afforded by a system which provides a water spray over the surface of the ship, or by a combination of insulation and a water spray system.

Section 3

Fire-extinguishing

3.1 Water monitors

3.1.1 The minimum number of monitors, their discharge rate, their range and their height of trajectory above sea level are to comply with the requirements of Table 3.1.1.

3.1.2 The monitors are to be so arranged that the required direction, range and height of trajectory can be achieved with the required number of monitors when they are operating simultaneously.

3.1.3 The monitors are to be capable of adequate adjustment in the vertical and horizontal direction and are to be so positioned that the jets will be unimpeded within the required range of operation. The horizontal angular movement of the monitors is to be at least 90°.

3.1.4 Means are to be provided for preventing the monitor jets from impinging on the ship's structure and equipment.

3.1.5 The monitors are to be of robust construction and their seating arrangements are to be of adequate strength for all modes of operation, particular attention being paid to shock loading when all the monitors are activated simultaneously.

3.2 Monitor controls

3.2.1 The activating and the maneuvering of the monitors are to be capable of remote control. The remote control station is to be arranged in a protected control room with a good general view. The valve control is to be designed to avoid water hammer.

3.2.2 The control system is to be designed in such a manner that normal operation can be restored within 10 minutes in case of any failure in the control system.

3.2.3 In case of electrical control systems, each control unit is to be provided with overload and short-circuit protection. In case of hydraulic or pneumatic control systems, the control power units are to be duplicated.

3.2.4 In addition to the remote control, local/manual control of each monitor is to be provided.

3.3 Foam monitor system (For class notation Agni 3)

3.3.1 In addition to the water monitors, the vessel is to be equipped with 2 foam monitors, each of a capacity not less than 5000 litres/minute with a maximum foam expansion ratio of 15 : 1.

Table 3.1.1 : Water monitor system capacities

Equipment	Class Notation			
	Agni 1	Agni 2		Agni 3
Minimum number of water monitors	2	3	4	4
Minimum discharge rate per monitor [m^3/h]	1200	2400	1800	2400
No. of pumps	1-2	2-4		2-4
Minimum total pump capacity [m^3/h]	2400	7200		9600
Minimum height of throw in [m[1)]]	45	70		70
Minimum length of throw in [m[2)]]	120	150		150
Minimum fuel capacity in hours [3)]	24	96		96
Number of hose connections each side of ship	4	8		8
Number of fireman's outfits	4	8		8

Notes:

1) Measured vertically from sea level to mean impact area at a horizontal distance of at least 70 [m] from the nearest part of the vessel.

2) Measured horizontally from the mean impact area to the nearest part of the vessel when all the monitors are in operation satisfactorily.

3) Capacity for continuous operation of all monitors to be included in the total capacity of the vessel's fuel oil tanks.

3.3.2 The foam system, together with the arrangements and location of monitors, is to give a height of throw at least 50 [m] above sea level when both monitors are used simultaneously with maximum foam generation.

3.3.3 The foam concentrate tank is to have a capacity for at least 30 minutes of maximum foam generation from both foam monitors. When determining the necessary quantity of foam concentrate, the admixture is assumed to be 5 per cent.

3.3.4 The foam generating system is to be of a fixed type with separate foam concentrate tank, foam-mixing unit and pipelines to the monitors. The water supply to the system may be taken from the main pumps for the water monitors and in such cases it may be necessary to reduce the main pump pressure to ensure correct water pressure for maximum foam generation.

3.3.5 Foam monitors are to be controlled in the manner given in 3.2 and the controls are to be located in the same control room as that for water monitors.

3.4 Pumps and piping

3.4.1 The pumps and their piping system which are intended for serving the monitors are not to be available for services other than fire-extinguishing and water spraying.

3.4.2 Where the pumps are used for fixed water spray systems, the piping is to be independent of that supplying the monitors. The water spray systems are to be adequately protected against overpressure.

3.4.3 The minimum total pump capacities required are shown in Table 3.1.1.

3.4.4 The piping system from the pumps to the water monitors is to be separate from the piping system to the hose connections required for mobile fire fighting equipment.

3.4.5 The piping systems are to have arrangements to avoid overheating of the pumps at low delivery rates.

3.4.6 All piping from seawater inlets to monitors is to be protected internally and externally against corrosion to a degree at least corresponding to hot galvanizing.

3.5 Mobile fire fighting equipment

3.5.1 Hose stations

3.5.1.1 Hose stations are to be provided on each side of the ship in accordance with Table 3.1.1.

3.5.1.2 Each hose station is to be provided with a hydrant, a hose and a nozzle capable of producing a jet or a spray and simultaneously a jet and a spray. The hoses are to be 15 [m] in length and not less than 38 [mm] nor more than 65 [mm] in diameter. Where hose stations are connected to the monitor supply lines, provision is to be made to reduce the water pressure at the hydrants to an amount at which each fire hose nozzle can be safely handled by one man. The water pressure shall be sufficient to produce a water jet throw of at least 12 [m].

3.5.2 Foam generator

3.5.2.1 Vessels with class notation "Agni 2 or 3" are to have a mobile high expansion foam generator with a capacity not less than 100 [m^3/minute] for fighting of external fires.

3.5.2.2 Foam-forming liquid is to stored in containers each of about 20 litres and suitable for mobile use. The total storing capacity of foam forming liquid is to be sufficient for 30 minutes continuous foam production.

3.6 Fireman's outfits

3.6.1 The number of fireman's outfits provided in addition to those provided in accordance with Pt.6, Ch.3, Sec.4.10 is to be in accordance with Table 3.1.1. They are to be stored in a safe position which is readily accessible from the open deck.

3.6.2 The composition of a fireman's outfit is to be as follows:

- Protective clothing of material to protect the skin from heat radiating from the fire and from burns and scalding by steam. The outer surface is to be water-resistant.

- Boots and gloves of rubber or other electrically non-conducting material.

- A rigid helmet providing effective protection against impact.

- An electric safety lamp (hand lantern) of an approved type with a minimum operating period of 3 hours.

- An axe having an insulated handle.

- A self-contained breathing apparatus which is to be capable of functioning for a period of at least 30 minutes and having a capacity of at least 1200 litres of free air. Spare, fully charged air bottles are to be provided at the rate of at least one set per required apparatus.

- For each breathing apparatus a fireproof lifeline of sufficient length and strength is to be provided and is to be capable of being attached by means of a snaphook to the harness of the apparatus or to a separate belt in order to prevent the breathing apparatus becoming detached when the lifeline is operated.

3.7 Recharging of equipment

3.7.1 A suitable air compressor for recharging the bottles used in the breathing apparatus of the fireman's outfits is to be provided. It is to be capable of recharging the bottles of the breathing apparatus required to be carried in accordance with Table 3.1.1 in a time not exceeding 30 minutes.

End of Chapter

Chapter 26

Diving Support Vessels and Diving Systems

Contents

Section 1

General

1.1 Application

1.1.1 The requirements of this Chapter are applicable to diving support vessels and diving systems. The Chapter covers design, construction and survey requirements of diving support vessels, diving systems and hyperbaric evacuation systems.

1.1.2 Vessels equipped with a diving system complying with the requirements of Section 3 and having diving support capability specified in Section 2 will be eligible for class notation “JUS”.

1.1.3 Diving systems covered by this Chapter may be fitted and operated from a ship, barge, mobile offshore platform or fixed offshore installation.

1.1.4 Surface and Saturation diving systems complying with the requirements would be eligible for Class notation “DS - SURF” or “DS - SAT” respectively. Diving systems built under the survey and in accordance with the Rules of IRS, using materials and components tested by IRS in conformity with its Rules, would receive the distinguishing mark 卐 before the Character of Class or Class Notation.

1.1.5 Classification of diving systems is carried out independent of the classification of the vessel.

1.1.6 Whilst the requirements of this Chapter are considered to meet the requirements of IMO Resolution A.831(19), as amended, the statutory requirements of the Flag Administration, where the ship, barge, mobile offshore platform or fixed offshore platform is registered, are to be complied with.

1.1.7 The certification of arrangements, systems and individual components based on recognised standards, codes, national regulations, etc., may be accepted subject to special consideration by IRS in each case.

1.1.8 The classification certificate of the diving system will indicate the name and, where applicable, the IMO number of the vessel on which it is installed. The following information will be indicated in the attachment to the classification certificate of the diving system :

- Description of the diving system including operational limitations and conditions of intended use;

- Codes and standards to which the diving system complies.

1.1.9 Diving systems classed by IRS would be entered in the Register Book. For diving systems of non-standard design, IRS may require additional checks/ tests/ surveys and may make appropriate entries in the Class Certificate and the Register Book.

1.1.10 In general, all diving systems are to undergo initial surveys for classification and periodical surveys thereafter, as defined in Pt.1, Ch.2 of the Rules. Detailed requirements for initial classification and survey of diving systems are covered in Pt. 1, Ch. 2, Sec. 18.

1.1.11 Operational records for diving systems are to be maintained in which details of operations (diving operations, maintenance, damages, repairs, etc.) are to be entered. The record is to be submitted to IRS Surveyors on request.

1.2 Assumptions

1.2.1 The classification of diving systems is based upon the assumption that:

- The diving systems would be properly maintained and operated by competent personnel;
- A pre-check procedure would be followed to ensure the proper functioning of all systems and components before start of each operation;
- The current, wave and wind conditions will be within the design limits for handling and positioning systems; and
- Any significant repairs or replacement of components of the diving system would be carried out to the satisfaction of the IRS Surveyors.

1.3 Definitions

1.3.1 For the purpose of this Chapter the terms used have the meanings defined in the following paragraphs unless expressly provided otherwise.

1.3.2 **Administration** means the Government of the State whose flag a ship or floating structure which carries a diving system is entitled to fly or in which the ship or floating structure is registered.

1.3.3 **Bottle** means a pressure container for the storage and transport of gases under pressure.

1.3.4 **Breathing gas/breathing mixture** means all gases/mixtures of gases which are used for breathing during diving operations.

1.3.5 **Surface compression chamber** means a pressure vessel for human occupancy with means of controlling the pressure inside the chamber.

1.3.6 **Depth** means the water depth or equivalent pressure, to which the diver is exposed to at any time during a dive or inside a surface compression chamber or a diving bell.

1.3.7 **Diving bell** means a submersible compression chamber, including its fitted equipment, for transfer of diving personnel under pressure between the work location and the surface compression chamber.

1.3.8 **Diving system** means the whole plant and equipment necessary for the conduct of diving operations.

1.3.8.1 **Fixed system** means a diving system installed permanently on ships or floating structures.

1.3.8.2 **Temporary system** means a diving system installed on ships or floating structures for a period not exceeding one year.

1.3.9 **Hyperbaric Evacuation System (HES)** means the whole plant and equipment necessary for the evacuation of divers in saturation from a surface compression chamber to a place where decompression can be carried out. The main components of a hyperbaric evacuation system include the hyperbaric evacuation unit, handling systems and life support system.

1.3.10 **Hyperbaric Evacuation Unit** means a unit whereby divers under pressure can be safely evacuated from a ship or floating structure to a place where decompression can be carried out.

1.3.11 **Handling system** means the plant and equipment necessary for raising, lowering and transporting the diving bell/ hyperbaric evacuation unit between the work location and the surface compression chamber.

1.3.12 **Hazardous areas** are those locations in which:

- an explosive gas-air mixture is continuously present, or present for long periods (zone 0);
- an explosive gas-air mixture is likely to occur in normal operation (zone 1);
- an explosive gas-air mixture it not likely to occur, and if it does it will only exist for a short time (zone 2).

1.3.13 **Life support system** means the gas supply, breathing gas system, decompression equipment, environmental control system and equipment required to provide a safe environment for the diving crew in the diving bell and the surface compression chamber under all ranges of pressure and conditions they may be exposed to during diving operations.

1.3.14 **Living compartment** means the part of the surface compression chamber which is intended to be used as the main habitation for the divers during diving operations and which is equipped for such purpose.

1.3.15 **Main components** of a diving system include the surface compression chamber, diving bell, handling system and fixed gas storage facilities.

1.3.16 **Mating device** means the equipment necessary for the connection and disconnection of a diving bell to a surface compression chamber.

1.3.17 **Maximum operating depth** of the diving system is the depth in [m] or feet of seawater equivalent to the maximum pressure for which the diving system is designed to operate.

1.3.18 **Pressure Vessel** means a container capable of withstanding an internal maximum working pressure greater than or equal to 1 bar.

1.3.19 **Umbilical** means the link between the diving support unit and the diving bell and may contain surveillance, communication and power supply cables, breathing gas and hot water hoses. The hoisting and lowering strength member may be part of the umbilical.

1.3.20 **Closed circuit breathing system** means the system for supply of breathing gas to the diver and saving of exhaled gases for recirculation after scrubbing and replenishing.

1.3.21 **Diver heating** means the system for actively heating the divers in the water or in the inner area.

1.3.22 **Inner area** means the areas which are inside the chambers and the bell.

1.3.23 **Outer area** means the areas of the diving system that are exposed to the atmospheric conditions during the operation, i.e. outside the inner system and the room or area that surrounds or contains the diving system.

1.3.24 **Normal cubic metres** [Nm^3] is taken as volume of gas [m^3] at standard conditions of 0°C and 1.013 bar.

1.3.25 **Category A Machinery Spaces** are those spaces and trunks to such spaces as defined in the International Convention for the Safety of Life at Sea, 1974, as amended.

1.3.26 **Control Station** is a station in which one or more of the control and indicator functions are located. These may include controls and /or indicators for operation of all vital life support conditions, pressure controls, hyperbaric evacuation system, launch and recovery system, automatic sprinkler, fixed fire detection and fire alarm systems, temperature, humidity etc.

1.4 Scope of Classification

1.4.1 The following parts and systems are covered by IRS certification of the diving systems (fitted onboard ship or as independent unit) and require to be inspected during manufacture and installation, as applicable:

- Chambers;
- Bell;
- Permanent gas containers;
- Other pressure vessels;
- Life support systems;
- Electrical systems;
- Fire protection, detection and extinction;
- Launch and recovery systems;
- Umbilicals;
- Pipes valves and fittings;
- Pumps and compressors;
- Helium reclamation plant;
- Gas analysers;
- Gas mixing units;
- Gas absorbers;
- Breathing systems;
- Depth gauges;
- Sanitary systems;
- Communication systems;
- Arrangement for hyperbaric rescue of divers in saturation.

1.5 Plans and particulars

1.5.1 Before commencement of construction, following plans/ particulars for diving related functions are to be submitted for approval/ information, as applicable:

a) For the total system

- Plans showing general arrangement of the diving system, location and supporting arrangement, locations of equipment, breathing gas storage, hazardous zones, interface with piping arrangement, electrical installations, etc

- Plans are to include information like maximum operating depth and maximum observation depth for the bell, maximum operation time, maximum number of divers in bell, maximum number of divers in chamber(s) and bell(s) and maximum operational sea state;

- Plans showing lay-out of control stations(s);

- Proposed programme for tests and trials of the system for normal operation and emergency use.

b) For pressure vessels

- Plans as required by Pt.4, Ch.5;

- Plans showing expansion allowances under working conditions for interconnected multi-vessels systems;

- Fabrication tolerances;

- Type of thermal insulation materials and particulars, e.g. flammability and specific heats of conductivity;

- Type of buoyancy materials and particulars, e.g. collapse water depth, specific weight, specific water absorption, etc.;

- Drawings and specifications of all windows including fabrication tolerances; and

- Media contained, filling pressures and temperatures;

- Calculations of thicknesses/ stresses and fatigue analysis.

c) Gas supply

- Piping diagrams and block diagrams for the entire gas supply system including valves and fittings;

- Details of umbilical structure;

- Proposed cleaning procedure for breathing gas system; and

- Details of gas analysis.

d) Life support system

- Piping diagrams, block diagrams and description of systems and equipment;

- Calculation of cooling and heating requirements;

- Description and plans of water supply and disposal systems;

- Description and design details of diver heating system;

- Details of valves and fittings; and

- Plans showing the arrangement and specifications of environmental control systems and equipment, diving crew facilities, sanitary and drainage systems.

e) Automation, communication and locating equipment

- General arrangement drawings/block diagrams of control equipment including list of measuring points;

- Description and details of the communication means between the diving control station and diving systems, including single line diagram;

- Equipment list covering sensors, instruments, etc.;

- Description of electronic components such as signal amplifiers, computers and peripheral units;

- General arrangement drawings and equipment lists for communication systems and signaling equipment; and

- Arrangement drawing and description of the TV system.

f) Electrical systems

- Single line distribution diagram and detailed diagram of the entire installation. The diagrams are to give information on full load, cable types and cross-sections, make, type and ratings of all fuse and switchgear;

- Failure scenarios, redundancy principles, emergency arrangement,etc;

- Key diagrams of control and alarm circuits for all consumers;

- Plans showing arrangements of batteries with information about their make, type and rating;

- Single line diagrams of the communication systems; and

- Complete list of components and documentation on any tests carried out on all electrical equipment intended to be installed in the chamber and the bell.

g) Fire protection, detection and extinction

- List of all materials to be installed in the inner area, where possible with data on and/or evaluation of flammability in conditions under which the materials are to be used; and

- Plans and specifications of fire detection, fire alarm and fire extinction equipment for both the inner and outer areas.

h) Handling, transfer and mating systems

- A description of the system with details of operating conditions;

- Installation drawings;

- Detailed plans of transfer equipment, lifting equipment, mating equipment, substructures of handling equipment including winches;

- Detailed plans of interchangeable components and fittings;

- Piping systems and instrumentation details of hydraulic/ pneumatic systems, as applicable;

- Details of control and protective systems; and

- Details of hoist and guide ropes.

i) Umbilicals

- Plans and specifications giving details regarding particulars of conductors, minimum breaking load, minimum diameter of pulleys and drums;

- Details regarding maximum design load, elastic properties, weight per unit length.

j) Hyperbaric evacuation system

- Description of system;
- General arrangement and detailed plans of evacuation system; and
- Details of handling system and power supply.

1.5.2 Diving System Documentation

1.5.2.1 Technical and Operation Manual

.1 The diving system technical and operation manual is to include, but not limited to the following:

- the description of the system

- the list of diving equipment with reference and name of the manufacturer

- the user instructions to operate the system

- the inspection and testing programme of the diving system when installed on-board

- the emergency evacuation plan when divers are in hyperbaric chamber, when relevant.

1.5.2.2 Planned Maintenance System (PMS)

.1 Details of a planned maintenance system as defined in IMCA D-018, '*Code of Practice for the Initial and Periodic Examination and Testing of Diving Plant and Equipment*' (as amended) are to be submitted. The PMS is to include the requirements for the periodic examinations, testing and routine replacement of the components. The PMS is to ensure the traceability of the maintenance works carried out on the diving plant.

Section 2

Requirements for Diving Support Vessels

2.1 General

2.1.1 The requirements specific to Diving Support Vessels for assignment of Class Notation “JUS” are covered in this section.

2.2 Stability and Position Keeping

2.2.1 The diving support vessel is to comply with the stability requirements stipulated for additional class notation “STS” in Pt. 5, Ch. 8 of the Rules.

2.2.2 The diving support vessel is to have a position keeping system for safe diving operations. For ships equipped with a dynamic positioning system, the class notation DP 2 or DP 3 is required. Anchoring systems may be accepted for position keeping provided they are generally in accordance with the requirements given in Chapter 10 of the Rules for the Construction and Classification of Mobile Offshore Drilling Units.

2.2.3 Communication systems with sufficient redundancy are to be provided between the control station of positioning system and dive control station. A manually operated alarm system is also to be provided.

2.3 Plans and Particulars

2.3.1 In addition to the plans/ documentation required for hull, machinery and systems, the plans listed in 1.5 are also to be submitted to IRS for approval.

2.3.2 Detailed plans, drawings and procedures are to be prepared for all installation activities of the diving system.

2.4 Location of Diving Equipment and Design Requirements

2.4.1 The location of diving systems is to be appropriate for carrying out safe diving operations without being affected by the operation of propellers, thrusters or anchors.

2.4.2 Diving systems are not to be located in hazardous areas designated as Zone 0, as defined in 1.3.

2.4.3 Diving systems or their parts (including hyperbaric evacuation systems) sited on decks are to be afforded reasonable protection against water, icing or any damage that may occur due to other ship operations.

2.4.4 Diving systems situated on open decks are not to be located in the vicinity of ventilation openings from machinery spaces, exhausts or ventilation outlets from galley. In general, a minimum distance of 6 [m] between ventilation outlets or exhausts and diving system ventilation inlets is considered sufficient.

2.4.5 Diving systems are not to be installed close to sources of harmful noise. In the outer areas, noise limits are to be maintained at 75 dB(A), so that personnel may be able to communicate with each other.

2.4.6 The diving system and breathing gas storage facilities are not to be located in machinery spaces unless the machinery is associated with the diving system.

2.5 Supporting Structures of Diving Equipment

2.5.1 Diving systems including equipment are to be permanently attached to the ship structure and provisions are to be made on the ship for this purpose. The fastening arrangements are to be able to meet the required survival conditions of the ship or floating structure.

2.5.2 In general, the supporting structures for diving systems are to be designed in accordance with the requirements of Part 3 of the Rules.

2.5.3 Special attention is to be paid to the design of supports for pressure vessels subject to expansion/ contraction due to temperature and pressure variations. Deflections of supports are to be considered in the design of the pressure vessel.

2.5.4 The supporting structure(s) of pressure vessels are to be able to withstand the loads during periodical hydrostatic testing with acceptable levels of deflections. Temporary supports may be considered during testing if necessary.

2.5.5 Supporting structures and foundations for handling systems and lifting appliances are to be designed according to Part 3 of the Rules and/ or other recognized standards.

2.5.6 A dynamic load factor of at least 2.2 is to be applied for supports of lifting appliances used for handling manned objects such as surface bells, baskets or Hyperbaric Evacuation Systems.

2.5.7 The side structure of the moon pool is to be strengthened for possible impact loads from diving equipment guided through the moon pool.

2.6 Sea Water Inlets

2.6.1 Design of sea inlets fitted in the hull of the diving support vessel is to be specially considered in order to protect the divers and the sea inlet systems.

2.6.2 The mesh or aperture size of any protective structure is to be such as to prevent any part of the diver or his equipment being drawn into the intake at the velocity which would occur during pump operation.

2.6.3 It is recommended that water current in the immediate vicinity of the sea inlet is not to exceed 0.5 [m/sec].

2.6.4 Recommendations available in IMCA AODC 055 '*Protection of Water Intake Points for Diver Safety*' (as amended), may be referred for more details.

2.7 Piping Systems for Oxygen and Mixed Gas

2.7.1 In general piping systems are to be designed in accordance with Pt. 4, Ch. 2 and Ch. 3 of the Rules. In addition, the following are to be ensured:

.1 Exhaust, venting and pressure relief gases from the diving system are to be released to the open air away from sources of ignition, personnel or other areas where the presence of those gases could be hazardous (such as engine room and galley exhausts). Means are to be provided to prevent any dangerous accumulation of gases.

.2 High pressure piping systems carrying mixed gas or oxygen are not to be located inside accommodation spaces and machinery spaces of category A or similar compartments.

.3 All high pressure piping is to be protected against mechanical damage.

.4 The system and arrangement of filters/ strainers are to be such as to maintain uninterrupted supply of gas to essential systems.

.5 Piping systems intended for use in breathing gas and oxygen systems are to be cleaned and tested for purity in accordance with an acceptable test method (for e.g. ASTM G93-03 '*Standard Practice for Cleaning Methods and Cleanliness Levels for Materials and Equipment used in Oxygen-enriched Environments*').

2.8 Gas Storage

2.8.1 Oxygen bottles are not to be stored near flammable substances. Oxygen is not to be stored or ducted in any form close to combustible substances or hydraulic equipment.

2.8.2 Oxygen bottles are to be stored in separate storage rooms with good ventilation arrangements. The rooms are to be provided with sensors for oxygen content giving an audio-visual alarm at a manned control station.

2.8.3 Two oxygen analyzers with audio-visual low level alarms are to be provided in enclosed spaces where gas mixtures with oxygen content less than 20% are stored.

2.8.4 These analyzers are to be mounted such that one monitors the upper level and another monitors the lower level of the space.

2.9 Electrical Systems

2.9.1 In general electrical systems are to be provided in accordance with Pt. 4, Ch. 8 of the Rules. Additional/ special requirements for systems and equipment serving diving systems are given in the following :

.1 Plans/ Documentation to be submitted

> .1 Design Document describing the philosophy of the overall electrical system with respect to operational modes, failure scenarios, redundancy principles, automatic changeover systems etc.
>
> .2 General arrangement showing location of all important electrical equipment for diving system;
>
> .3 Single line distribution system diagrams for the whole installation with information on full load, cable types and

cross sections, and make, type and rating of fuse and switchgear for all distribution circuits;

.4 Calculations on load balance, including emergency consumption and battery capacities;

.5 Multi-wire diagrams of control and alarm circuits for all motors or other consumers;

.6 Plans showing arrangements of batteries, their make, type and capacity;

.7 Plans showing arrangement and single line diagrams of the communication system.

.2 Design Requirements

.1 All electrical equipment and installations, including power supply arrangements, are to be designed for the environment in which they will operate to minimize the risk of fire, explosion, electrical shock and emission of toxic gases to personnel, and galvanic action of the surface compression chamber or diving bell;

.2 Electrical cables are not to be routed close to gas piping;

.3 In the event of failure of the main source of electrical power supply to the diving system an independent source of electrical power is to be available for the safe termination of the diving operation;

.4 The ship's emergency source of electrical power may be used as an emergency source of electrical power for the diving system if it has sufficient capacity to supply the diving system and the emergency load for the vessel simultaneously;

.5 The alternative source of electrical power is to be located outside the space containing the main source of power;

.6 Main and emergency lighting are to be provided in all critical handling areas.

2.10 Fire Protection

2.10.1 The requirements for fire protection in Part 6 of the Rules are to be complied with, in general. Additional requirements for fire protection of areas containing diving equipment, auxiliaries and support systems are laid down in the following paragraphs.

2.10.2 Plans and Documentation

.1 Arrangement drawings of “outer area” spaces indicating the fire protection of the structural boundaries of these spaces. Details of insulation materials used are also to be provided..2 Plans and specifications of fire detection and fire extinguishing systems for ‘outer areas’;

2.10.3 Structural Fire Protection Requirements

.1 Boundaries separating enclosed “outer areas” from other enclosed spaces are to have A-60 fire integrity. Outer areas may be sub-divided into several spaces by A-0 class boundaries.

.2 All doors between “outer area” and other adjacent enclosed spaces are to be of self-closing type.

.3 At least one of the required escape routes from spaces not being part of “outer area” is to be independent of “outer area”.

.4 Insulation materials used in the diving system are to be of fire-retardant type.

.5 Enclosed “outer areas” are to have separate mechanical ventilation with minimum 8 air changes per hour.

2.10.4 Fire Detection and Alarm Systems

.1 The following requirements, as applicable, are to be complied with for outer areas in addition to the requirements in Part 6:

(a) The section or loop of fire detectors covering the “outer area” is not to cover other spaces;

(b) Fire detector panel is to be placed on the bridge with repeater panel at dive control room and in machinery control room;

(c) A visual alarm repeater is also to be situated at the diving control station.

2.10.5 Fire Extinguishing Systems

.1 Enclosed “Outer areas” situated are to be provided equipped with a fixed, manually operated fire-extinguishing system. The system is to be capable of being operated from the dive control station, bridge and/ or other locations, as necessary.

.2 The fire-extinguishing system is to be sufficient to cover the largest area bounded by A-0 class divisions.

.3 A fixed fire extinguishing system complying with the requirements of Part 6 of any of the following types is to be provided:

(a) Pressure water spraying system, approved for use in machinery spaces of Category A; or

(b) Fixed gas system.

.4 The fixed gas system is to be of a type non-hazardous to human beings,in the concentration expected in the space.

.5 When pressure vessels are situated in enclosed spaces, a manually actuated water spray system having an application rate of 10 [lit/ m^2/ min] of the horizontal projected area is to be provided to cool and protect such pressure vessels in the event of external fire.

.6 Fire hoses and nozzles provided on open decks are considered sufficient where pressure vessels are located in such areas.

.7 Where diving systems are located in open decks, the fire extinguishing arrangements in “outer areas would be specially considered.

2.10.6 Personnel Protection

.1 In addition to the fire fighters outfits required by Part 6 of the rules, an additional set is to be provided for each person required for the operation of the diving system during a fire.

.2 Control stations manned during bell recovery or launching of hyperbaric evacuation unit are to be provided with breathing apparatus.

2.10.7 Portable Fire-Extinguishers

.1 The spaces containing diving system and equipment are to be provided with sufficient number of portable fire-extinguishers so that one extinguisher is available in every 10 [m] walking distance.

Section 3

Requirements for Diving Systems

3.1 General

3.1.1 Requirements applicable to diving systems for assignment of class notation “**DS-SURF**” and “**DS-SAT**” are covered in this section.

3.1.2 In general, the notation “**DS-SURF**” is to be assigned for diving systems, where diving operations are performed at such depths and durations that the decompression is carried out from the surface without resorting to the use of a closed diving bell.

3.1.3 In general, the notation “**DS-SAT**” is to be assigned to saturation diving systems, where equipment is provided such that divers can live in a pressurized environment for several days or weeks. Divers are generally decompressed to surface pressure only once, at the end of their work.

3.1.4 As far as reasonable and practicable a diving system is to be designed to minimize human error and constructed so that the failure of any single component (determined, if necessary by an appropriate risk assessment) would not lead to a dangerous situation.

3.1.5 Diving systems and components thereof are to be designed for the service conditions under which they are certified to operate.

3.1.6 Materials for diving system components are to be suitable for their intended use.

3.1.7 All components in a diving system are to be designed, constructed and tested in accordance with applicable International or National standards recognised by IRS or proprietary specifications acceptable to IRS.

3.1.8 In the design of pressure vessels including accessories such as doors, hinges, closing mechanisms and penetrators, the effects of rough handling and accidents are to be considered in addition to design parameters such as pressure, temperature, vibration, operating and environmental conditions.

3.1.9 All components in a diving system are to be so designed, constructed and arranged as to permit easy cleaning, disinfection, inspection and maintenance.

3.1.10 A diving system is to include the control equipment necessary for safe performance of diving operations.

3.1.11 Diving systems generally include, but are not limited to, the items listed in Table 3.1.11

Table 3.1.11 : Indicative list of diving equipment

Items	Saturation diving	Surface diving
Closed diving bell	*	
Wet diving bell or diver basket		*
Deck decompression chamber	*	*
Breathing supply system	*	*
Handling systems for the diving bell	*	*
Diving control stand	*	*
Clamping and under pressure transfer system	*	
Devices for controlling the atmosphere	*	*
Devices for the recovery and the purification of breathing gases	*	*
Means of production of hot water	*	
Hyperbaric Evacuation System	*	

3.2 Requirements for Diving Systems and Components

3.2.1 Environmental Conditions

3.2.1.1 Diving systems together with their accessories and fitted equipment are to be designed for the environmental conditions likely to occur at the point of installation or work location but in any case not less than that required by Table 3.2.1.1 and Table 3.2.1.2.

Table 3.2.1.1 : Minimum Design Inclinations

Component location	**Athwartships**		**Fore-and-Aft**	
	Static	**Dynamic**	**Static**	**Dynamic**
Compression chambers and other surface installations				
On ship	± 15°	± 22.5°	± 5°	± 10°
On mobile offshore unit (on semi-submersible)	± 15°	-	± 15°	-
Diving bells and components therein	± 22.5°	± 45°	-	-

Table 3.2.1.2 : Minimum Environmental Conditions

Location	**Temperature**	**Relative Humidity**	**Other Conditions**
In chambers	5 to 55°C	100%	Salty air
Outside chambers in air [1,2]	- 10 to + 55°C	100%	
Outside chambers in water	- 2 to 32°C	-	Salt water containing 3.5% salt
Control rooms	5 to 55°C	80%	-

1 In the case of facilities installed on the open deck, allowance is to be made for icing and temporary inundation with salt water and spray.
2 Other values will be specially considered for installation in closed spaces.

3.2.2 Surface Compression Chambers

.1 A diving system is to, as a minimum, include either one surface compression chamber with two separate compartments, or two interconnected separate chambers so designed as to permit ingress or egress of personnel while one compartment or chamber remains pressurized. All doors are to be so designed that locking mechanisms, if provided, can be operated from both sides.

.2 Where a surface compression chamber is to be used in circumstances in which a person is intended to remain under pressure for a continuous period of more than 12 hours, it is to be so arranged as to allow most divers to stand upright and to stretch out comfortably on their bunks. The smaller of the two compartments is to be large enough for at least two persons. One of these compartments is to be a living compartment.

.3 The living compartment and other compartments intended to be used for decompression are to have a lock through which provisions, medicine and equipment may be passed into the chamber while its occupants remain under pressure.

.4 Locks are to be designed to prevent accidental opening under pressure and, where necessary, interlocks are to be provided for this purpose.

.5 Each pressure compartment is to have view ports to allow observation of all occupants from the outside.

.6 A surface compression chamber is to provide a suitable environment and facilities for the persons who use it, having regard to the type and duration of the diving operation. Where the chamber is intended to be occupied for more than 12 hours, toilet facilities are also to be provided. Toilet facilities capable of discharging the waste to the outside are to be fitted with suitable interlocks.

.7 The diving system is to be capable of allowing the safe transfer of a person under pressure from the diving bell to the surface compression chamber (and vice versa).

.8 Facilities are to be provided for keeping the partial pressure of the CO_2 in the chamber atmosphere permanently below 0.005 bar assuming a CO_2 production rate of 0.05 [Nm^3/hour] per diver.

.9 Diving systems using mixed gas and designed for operating periods of more than 12 hours at a time are to be capable, under steady conditions, of keeping the temperature in the surface compression chamber constant to ± 1°C in the 27 - 36°C range while maintaining a relative humidity of at least 50 per cent.

.10 In the steady state, the permanent noise level (over 8 hours) in the living compartment and surface compression chamber is not to exceed 65 dB(A).

3.2.3 Diving bells

.1 A diving bell is to :

- be provided with adequate protection against mechanical damage during handling operations;
- be equipped with one extra lifting point designed to take the entire dry weight of the bell including ballast and equipment as well as the weight of the divers staying on in the bell; and
- be equipped with means whereby each diver using the bell is able to enter and leave it safely as well as with means for taking an unconscious diver up into a dry bell.
- be fitted with a manifold (which is clearly marked and suitably protected), at a suitable point close to the main lifting attachment which is to include connections to the following main services :

    ¾ inch NPT (female) - for hot water
    - ½ inch NPT (female) – for breathing mixture

.2 Diving bell doors are to be so designed as to prevent accidental opening during normal operations. All doors are to be so designed that locking mechanisms, if provided, can be operated from both sides.

.3 A diving bell is to provide a suitable environment and facilities for the persons who use it, having regard to the type and duration of the diving operation.

.4 Each diving bell is to have view ports that as far as practicable allow an occupant to observe divers outside the bell.

.5 Diving bells are to be so designed as to provide adequate space for the number of occupants envisaged, together with the equipment.

.6 In diving bells, it is to be possible to keep the partial pressure of the CO_2 below 0.015 bar as a minimum requirement assuming a CO_2 production rate as specified in 3.2.2.8. Under emergency conditions, it is to be possible to hold the partial pressure of CO_2 below 0.02 bar for at least 24 hours.

3.2.4 Pipes, Valves, Fittings and Hoses

.1 Pipe systems are to be so designed as to minimize the noise inside the diving bell and surface compression chamber during normal operation.

.2 A surface compression chamber is to be equipped with such valves, gauges and other fittings as are necessary to control and indicate the internal pressure and safe environment of each compartment from outside the chamber at a centralized position.

.3 Valves, gauges and other fittings are to be provided outside the bell as necessary to control and indicate the pressure and safe environment within the diving bell. The external pressure on the diving bell is also to be indicated inside the bell.

.4 All pipe penetrations on chambers are to be fitted with two shutoff devices as close to the penetration as practicable. Where appropriate, one device is to be a non-return valve.

.5 All surface compression chambers and diving bells which may be pressurized separately are to be fitted with over pressure alarms or pressure relief valves. If pressure relief valves are fitted, a quick-operating manual shutoff valve is to be installed between the chamber and the pressure relief valve and is to be wired opened with a frangible wire. This valve is to be readily accessible to the attendant monitoring the operation of the chamber. All other pressure vessels and bottles are to be fitted with a pressure relief device.

.6 Piping systems which may be subjected to a higher pressure than designed for are to be fitted with a pressure relief device.

.7 All materials used in oxygen system are to be compatible with oxygen at the working pressure and flow rate.

.8 The use of high-pressure oxygen piping is to be minimized by the fitting of pressure reducing devices, as close as practicable to the storage bottles.

.9 Flexible hoses, except for umbilicals, are to be reduced to a minimum.

.10 Hoses for oxygen, as far as practicable, are to be of fire-retardant construction.

.11 Piping systems carrying mixed gas or oxygen under high pressure are not to be arranged inside accommodation spaces, engine rooms or similar compartments.

.12 Exhaust lines are to be fitted with an anti-suction device on the inlet side.

.13 Gases vented from the diving system are to be vented to the open air away from sources of ignition, personnel or any area where the presence of those gases could be hazardous.

.14 All high-pressure piping is to be well protected against mechanical damage.

.15 Piping systems containing gases with more than 25 per cent oxygen are to be treated as systems containing pure oxygen.

.16 Oxygen systems with pressure greater than 1.72 bar must have slow opening shutoff valves except pressure boundary shutoff valves.

3.2.5 Breathing gas supply, storage and temperature control

.1 Each surface compression chamber and diving bell is to be fitted with adequate equipment for supplying and maintaining the appropriate breathing mixtures to its occupants at all depths down to maximum operating depth. When adding pure oxygen to the chamber, a separate piping system is to be provided.

.2 In addition to the system mentioned in 3.2.5.1 each surface compression chamber and diving bell is to contain a separately controlled built-in breathing system for oxygen, therapeutic gas or bottom mix gas with at least one mask per occupant stored inside each separately pressurized compartment and means are to be provided to prevent any dangerous accumulation of gases.

.3 The diving bell is to be designed with a self-contained breathing gas system capable of maintaining a satisfactory concentration of breathing gas for the occupants for a period of at least 24 hours at its maximum operating depth.

.4 Oxygen bottles are to be installed in a well-ventilated location.

.5 Oxygen bottles are not to be stored near flammable substances.

.6 The diving system and breathing gas storage facilities are not to be sited in machinery spaces if the machinery is not associated with the diving system. Where, due to the requirements of diving operations, systems are sited in hazardous areas, the electrical equipment is to comply with the requirements for such equipment in hazardous areas. Diving systems are not permitted in hazardous areas designated as Zone 0.

.7 A diving system is to include adequate plant and equipment to maintain the divers in safe thermal balance during normal operations.

.8 Means are to be provided to maintain the divers within the diving bell in thermal balance in an emergency for at least 24 hours. Such requirements may be satisfied by the use of passive means carried in the bell.

.9 For piping systems and gas storage bottles/pressure vessels the following colour code is to be used:

Name	Symbol	Colour Code
Oxygen	O_2	White
Nitrogen	N_2	Black
Air	Air	White and black
Carbon dioxide	CO_2	Grey
Helium	He	Brown
Oxygen-helium mix gas	O_2He	White and brown

In addition, each bottle/ pressure vessel is to be marked with the name and symbol given above of the gases it contains. The marking and colour coding of the gas storage bottles are to be visible from the valve end.

3.2.6 Handling system for diving bells

.1 A diving system is to be equipped with a main handling system to ensure safe transportation of the diving bell between the work location and the surface compression chamber.

.2 The handling system is to be designed with adequate safety factors, in accordance with recognised codes of construction, considering the environmental and operating conditions, including the dynamic loads which are encountered while handling the diving bell through the air-water interface.

.3 The handling system is to enable smooth and easily controllable handling of the diving bell.

.4 The lowering of diving bells under normal conditions is not to be controlled by brake, but by the drive system of the winches.

.5 If the energy supply to the handling system fails, brakes are to be engaged automatically.

.6 In the event of single component failure of the main handling system, an alternative means is to be provided whereby the bell can be returned to the surface compression chamber. In addition, provisions are to be made for emergency retrieval of the bell if the main and alternative means fail. If this involves buoyant ascent, the bell is to have sufficient stability to maintain a substantially upright position and means are to be provided to prevent accidental release of the ballast weights.

.7 Handling systems and mating devices are to enable easy and firm connection or disconnection of a diving bell to a surface compression chamber, even under conditions where the support ship or floating structure is rolling, pitching or listing to predetermined angles.

.8 Where a power actuating system is used for mating operations, an auxiliary power actuating system or an appropriate means are to be provided to connect a diving bell to a surface compression chamber, in the event of failure of the normal power actuating system.

3.2.7 Other pressure vessels not intended for human occupancy

.1 Special attention is to be paid to the design and choice of material for the construction of pressure vessels containing oxygen.

.2 Oxygen and gases with an oxygen volume percentage higher than 25 per cent are to be stored in bottles or pressure vessels exclusively intended for such gases.

3.2.8 Interface between diving system and the ship or floating structure

.1 The diving system and breathing gas facilities are to be arranged in spaces or locations which are adequately ventilated and provided with suitable electric lighting.

.2 When any part of the diving system is sited on deck, particular consideration is to be given to providing reasonable protection from the sea, icing or any damage which may result from other activities on board the ship or floating structure.

.3 Provision is to be made to ensure that the diving system and auxiliary equipment are securely fastened to the ship or floating structure and that adjacent equipment is similarly secured. Consideration is to be given to the relative movement between the components of the system. In addition, the fastening arrangements are to be able to meet any required survival conditions of the ship or floating structure.

3.2.9 Fire protection, detection and extinction

.1 All materials and equipment used in connection with the diving system are to be, as far as is reasonably practicable, of fire-retardant type in order to minimize the risk of fire and sources of ignition.

.2 Spaces in the interior of ships or floating structures in which the diving or its auxiliary equipment is carried are to be provided with structural fire protection in a way similar to control stations (as defined in Pt.6, Ch.3) bounding main zones.

.3 Interior spaces containing diving equipment such as surface compression chambers, diving bells, gas storage, compressors and control stands are to be covered with an automatic fire detection and alarm system and a suitable fixed fire-extinguishing system.

.4 Portable fire extinguishers of approved types and designs are to be distributed throughout the space containing the diving system. One of the portable fire-extinguisher is to be stowed near the entrance to that space.

.5 When pressure vessels are situated in enclosed spaces, a manually actuated water spray system having an application rate of 10 [lit/m^2/per minute] of the horizontal projected area is to be provided to cool and protect such pressure vessels in the event of external fire. When pressure vessels are situated on open decks, fire hoses may be considered as providing the necessary protection.

.6 Each compartment in a surface compression chamber is to have a suitable means of extinguishing a fire in the interior which would provide rapid and efficient distribution of the extinguishing agent to any part of the chamber.

3.2.10 Electrical Systems

.1 All electrical equipment and installations, including power supply arrangements, are to be designed for the environment in which they will operate to minimize the risk of fire, explosion, electrical shock and emission of toxic gases to personnel, and galvanic action of the surface compression chamber or diving bell.

.2 Each surface compression chamber and diving bell are to have adequate means of normal and emergency lighting to allow an occupant to read gauges and operate the system within each compartment.

3.2.11 Control Systems

.1 The diving system is to be so arranged as to ensure that centralized control of the safe operation of the system can be maintained under all weather conditions.

.2 As a minimum, facilities are to be provided at the central control position to monitor the values of the following parameters for each occupied compartment:

Compartments	Parameters	
	Surface compression chamber	**Diving bell**
Pressure or depth [1]	X	X[2]
Temperature [1]	X	
Humidity	X	
Oxygen partial pressure [1]	X	X
CO_2 partial pressure	X	X

1 These parameters are to be indicated continuously.

2 Pressure or depth both inside and outside bell is to be indicated.

.3 Provision is to be made within the bell for an independent means of monitoring oxygen and carbon dioxide levels.

.4 The pressure gauges of compression chambers are to give a reading accurate to $\pm$ 0.3 per cent of the full instrument scale subject to a maximum deviation of 30 [cm] of water column. All other pressure gauges are to be accurate to 1 per cent of the full instrument scale.

3.2.12 Communications and Relocation Systems

.1 The communication system is to be arranged for direct two-way communication between the control stand and:

- diver in water
- diving bell
- each compartment of the chambers
- diving system handling positions
- dynamic positioning room
- bridge, ship's command center or drilling floor.

.2 Alternative means of communication with divers in the surface compression chamber and diving bell are to be available in emergency.

.3 Each surface compression chamber and diving bell is to be connected to a speech unscrambler when used with gas systems, including helium.

.4 A self-contained through-water communication system is to be provided for emergency communication with diving bells when operating under water.

.5 A diving bell is to have an emergency locating device with a frequency of 37.5 [kHz] designed to assist personnel on the surface in establishing and maintaining contact with the submerged diving bell if the umbilical to the surface is severed. The emergency locating device is to include the following components:

.1 Transponder

.1 The transponder is to be provided with a pressure housing capable of being operated to a depth of at least 200 [m] containing batteries and equipped with salt water activation contacts. The batteries are to be of the readily available “alkaline” type and, if possible, be interchangeable with those of the diver and surface interrogator/ receiver.

.2 The transponder is to be designed to operate with characteristics as indicated in Table 3.2.12.5.1.2

.2 Diver-held interrogator/ receiver

.1 The interrogator/ receiver is to be provided with a pressure housing capable of operating to a depth of at least 200 [m] with pistol grip and compass. The front end is to contain the directional hydrophone array and the rear end, the three-digit LED display readout calibrated in metres. Controls are to be provided for "on/ off receiver gain" and "channel selection". The battery pack is to be of the readily available "alkaline" type and, if possible, be interchangeable with that of the interrogator and transponder.

.2 The interrogator/ receiver is to be designed to operate with characteristics as indicated in Table 3.2.12.5.2.2

3.2.12.6 In addition to the communication systems referred to above, a standard bell emergency communication tapping code is to be adopted, as given in Table 3.2.12.6, for use between persons in the bell and rescue divers.

A copy of this tapping code is to be displayed inside and outside the bell and also in the dive control room.

Table 3.2.12.5.1.2 Transponder Characteristics
Common emergency reply frequency : 37.5 [kHz]
Individual interrogation frequencies - Channel A : 38.5 ± 0.05 [kHz] - Channel B : 39.5 ± 0.05 [kHz
Receiver Sensitivity : 15 dB referred to 1 [µbar]
Minimum Interrogation pulse width : 4 [ms]
Turnaround delay : 125.7 ± 0.2 [ms]
Reply frequency : 37.5 ± 0.05 [kHz]
Maximum interrogation rates - More than 20% of battery life remaining : Once per second - Less than 20% of battery life remaining : Once per 2 seconds
Minimum transponder output power : 85dB referred to 1 µbar at 1 m
Minimum transducer polar diagram : -6dB at ± 135° solid angle, centered on the transponder vertical axis and transmitting towards the surface
Minimum listening life in water : 10 weeks
Minimum battery life replying at 85 dB : 5 days

Table 3.2.12.5.2.2 Interrogator/ Receiver Characteristics
Common emergency reply frequency : 37.5 [kHz]
Individual interrogation frequencies - Channel A : 38.5 [kHz] - Channel B : 39.5 [kHz]
Minimum transmitter output power : 85dB referred to 1µbar at 1 m
Transmit pulse : 4 [ms]
Directivity : ± 15°
Capability to zero range on transponder
Maximum detectable ranges : more than 500 [m]

Table 3.2.12.6 Standard Bell Emergency Tapping Code

Tapping Code	Situation
3.3.3	Communication opening procedure (inside and outside)
1	Yes or affirmative or agreed
3	No or negative or disagreed
2.2	Repeat please
2	Stop
5	Have you a got a seal?
6	Stand by to be pulled up
1.2.1.2	Get ready for through water transfer (open your hatch)
2.3.2.3	You will NOT release your ballasts
4.4	Do release your ballast in 30 minutes from now
1.2.3	Do increase your pressure
3.3.3	Communication closing procedure (inside and outside)

3.3 Classification and Surveys of Diving Systems

3.3.1 Classification of diving systems built under survey of IRS:

a) All equipments/ components specified in 1.4 are required to be manufactured under survey of IRS Surveyors.

b) All systems are to be installed and tested under the supervision and to the satisfaction of IRS Surveyors.

3.3.2 Classification of diving systems not built under survey of IRS:

3.3.2.1 Details of the diving system, as required by 1.5, together with copies of manufacturer certificates for all components are to be submitted for review;

3.3.2.2 Upon satisfactory review of the documents stated in (a) above, a survey of the installation would be carried out by IRS Surveyors, based upon which the classification of the installation would be considered by IRS;

3.3.2.3 The documentation related to functional tests is to be submitted and where necessary, individual tests are to be repeated;

3.3.2.4 Existing Class and period of Class, as well as any requirements which have been made conditional upon the existing Class are to be intimated to IRS;

3.3.2.5 If the diving system holds the Class of another recognized Classification Society, the survey of individual parts may be deferred pending the next due date. A survey of these parts within the scope of an Annual Survey may be sufficient.

3.3.3.6 Special attention is to be paid to the following:

a) All decompression chambers, bells and other pressure vessels;

b) Safety valve arrangement on pressure vessels;

c) Gas storage, especially oxygen storage with regards to hazards during a potential fire;

d) Fire detection and fire protection arrangements;

e) Electrical installations, especially installations in hazardous areas;

f) Strength of structure supporting the diving equipment.

3.3.3 Suspension/ retention/ withdrawal of Class

.1 In general, the suspension/ retention/ withdrawal of Class of diving systems is to be in accordance with the provision of Pt.1, Ch. 1 of the Rules. The following aspects are to be additionally noted for diving systems:

.2 The period of Class of permanently installed diving systems would be identical to that of the machinery plant of the diving support ship or floating structure. The Class will be maintained as long as the diving system is subjected to all prescribed surveys, and any modifications and repairs found to be necessary are carried out to the satisfaction of IRS.

.3 If the diving system is not subjected to the prescribed surveys at their due dates, the Class would be suspended.

.4 If the diving system has suffered damage affecting its Class or if such damage may be assumed, a survey is to be performed before diving operations commence. IRS is to be notified of such damage as a matter of course.

.5 Where it is found that the diving system no longer complies with the requirements of the Rules on the basis of which the Class was assigned, or if the operator fails to carry out repairs or alterations considered necessary by IRS within a specified period, as agreed upon, the Class of the diving system will expire.

.6 If the repairs or modifications required by IRS have been carried out and the system is subjected to a Re-classification Survey, the original Character of Classification may be reinstated. This survey is to be carried out in accordance with the requirements for a Class Renewal Survey.

.7 For diving systems which are out of operation for some time or their diving support vessel, floating structure or offshore plant is laid up; the period of Class will remain unchanged. On request, surveys which fall due may be deferred until the diving system is replaced into service. The total scope of the surveys required thereafter would be determined by IRS for each case individually.

3.3.4 Surveys during Construction

3.3.4.1 Survey during construction and installation of the diving system will include the verification of the following items:

a) Compliance of the design of the diving system, scantlings and arrangements with the approved plans, IRS rule requirements, applicable national regulations and specified standards;

b) Certification of materials and components as per the Rule requirements;

c) Compliance with the fabrication tolerances and to the requisite quality standards;

d) Cleaning of piping systems conducting gas in life support systems in accordance with an approved cleaning procedure;

e) Cleaning and sealing of Gas cylinders;

f) All tests are carried out as per requirements.

3.3.4.2 The extent and method of survey is to be agreed prior to the work being carried out.

3.3.4.3 Tests/trials

.1 A comprehensive test plan is to be submitted for approval for carrying out tests after completion of installation of the diving system. This plan is to include testing details for, at least the following :

- Pressure tests
- Gas leakage tests
- Handling systems
- Life support systems
- Safety systems
- Electrical systems
- Instrumentation
- Environmental control systems
- Sea trials.

3.3.4.4 Leak Test

.1 Leak testing is to be carried out as per approved procedures. Details of leak tests are given in Pt.1, Ch. 2, 18.3.1.1.1.

3.3.4.5 Pressure Test

.1 Pressure tests are also to be carried out as per approved procedures. Details of pressure tests are provided in Pt.1, Ch. 2, 18.4.2.

.2 The following equipment/ systems are to be tested for hydrostatic pressure in accordance with recognized standards or design codes:

- New chambers and bells
- New gas cylinders
- New air and gas storage tanks
- New hot water tanks
- New piping

3.3.4.6 Pressure Vessels for Human Occupancy

.1 The manufacturers of pressure vessels for human occupancy are to be approved by IRS, when the pressure vessels are certified by IRS.

.2 The pressure vessels are to be designed and manufactured to internationally recognized codes/ standards.

.3 ASME PVHO-1 “Safety Standard for Pressure Vessels for Human Occupancy” is to be used for design of acrylic plastic windows.

3.3.4.7 In addition to the above, the scope of initial survey of other items/ components of the diving systems is as indicated in Table 3.3.4.7

Table 3.3.4.7 Initial Survey Requirements for Diving Systems[1]	
Pressure Equipment	
Pressure Vessels for Human Occupancy	
Examine/ verify (as applicable)	- certified materials are used; - sufficient strength in foundations and support for chambers and gas cylinders; - vessel is constructed in accordance with approved drawings; - flanges, sealing surfaces, openings for windows and hatches are satisfactory with regard to tolerances and for sealing systems; - out of roundness for vessels intended for external pressure are within tolerances; - welds are tested; - pressure tests upon completion are satisfactory.
Gas Storage	
Examine (as applicable)	As per the requirements for renewal survey
Pressure Vessels in Supply and Return Lines	
Examine (as applicable)	As per the requirements for renewal survey
Pumps and Compressors	
Examine and test (as applicable)	As per the requirements for renewal survey
System components including piping, umbilicals, hoses, valves, filters	
Examine and test (as applicable)	- Piping systems to be tested to 1.5 x the design pressure; - Cleaning of the hoses, piping and mountings to be undertaken carefully to ensure that the oxygen system is free from impurities like oil, grease etc, that may cause a fire hazard; - Leakage test of total deep diving system to be carried out with heliox mixture, after installation of piping.
Controls	
Gas Supply Control	
Examine/ Verify (as applicable)	As per the requirements for renewal survey
Gas Distribution System	
Examine/ Verify (as applicable)	As per the requirements for renewal survey
Depth/ Pressure Control	
Examine/ Verify (as applicable)	As per the requirements for renewal survey
Temperature and Humidity Control	
Examine/ Verify (as applicable)	As per the requirements for renewal survey
Gas Contamination Analysis	
Examine/ Verify (as applicable)	As per the requirements for renewal survey
Sanitary/ Domestic Systems	
Examine/ Verify (as applicable)	As per the requirements for renewal survey
Auxiliary Services to Life Support Equipment	
Examine/ Verify (as applicable)	- Electrical components installed inside chambers/ bells are to be of a construction suitable to withstand high humidity and oxygen atmosphere content; - Components installed outside bell are to be of watertight type and pressure tested to at least 1.3 x maximum design pressure.
Communication	
Examine/ Verify (as applicable)	Primary, secondary, emergency means of communication and alarms to be examined as per the requirements for renewal surveys.

Table 3.3.4.7 (Contd.)	
Launch and Recovery Systems	
General	
Examine/ Verify (as applicable)	For submergence launch and recovery system: (i) Examine all strength members as per approved drawings, certificates for hoisting ropes/ wires, books, sheaves, shackles etc (ii) Load test (including static and running loads[2]) of all lifting equipment. Bell launch and recovery systems to be tested as integral units. (iii) Test of emergency bell retrieval procedures; For surface launch and recovery : (i) As per the requirements for renewal survey
Controls	
Examine/ Verify (as applicable)	As per the requirements for renewal survey
Auxiliary services to launch and recovery system	
Examine/ Verify (as applicable)	Pipes and hoses to be tested to 1.5 x the maximum allowable working pressure (MAWP)
Safety Equipment	
Examine/ Verify (as applicable)	As per scope of annual, third annual survey and renewal surveys
Notes 1 : Requirements for renewal surveys of diving systems are given in Section 18 of Pt. 1, Ch. 2 2 : Running load test to be carried out at 1.25 x the safe working load.	

3.3.5 Surveys after Construction

3.3.5.1 The periodical surveys for diving support vessels are to be carried out in accordance with the applicable requirements of Pt. 1, Ch. 2.

3.3.5.2 Periodical surveys of diving systems fitted permanently onboard the ships are to be harmonised with those for the ships.

3.3.5.3 Periodical surveys of permanently fitted diving systems, independent diving systems or diving systems fitted temporarily onboard the ships are to be carried out in accordance with the requirements stipulated in Pt. 1, Ch. 2, Sec. 18 of the Rules.

Section 4

Evacuation Systems

4.1 General

4.1.1 An evacuation system is to be provided with sufficient capacity to evacuate all divers under pressure, in the event of the ship having to be abandoned, and is to be in accordance with the provisions of the Guidelines and Specifications for Hyperbaric Evacuation Systems (HES), IMO Res A.692(17), as amended.

4.1.2 Statutory requirements of the Flag Administration, where the ship, barge, mobile offshore platform or fixed offshore platform is registered, are to be complied with.

4.2 Design Requirements

4.2.1 The design and construction of the hyperbaric evacuation system is to be such that it is suitable for the environmental conditions envisaged, account being taken of the horizontal or vertical dynamic snatch loads that may be imposed on the system and its lifting points particularly during evacuation and recovery.

4.2.2 The hyperbaric evacuation unit is to be capable of being recovered by a single point lifting arrangement. Means are to be provided on the unit to permit a swimmer to hook on or connect the lifting arrangement.

4.2.3 In the design of pressure vessels including accessories such as doors, hinges, door landings, closing mechanisms, penetrators and viewports, the effects of rough handling are to be considered in addition to design parameters such as pressure, temperature, vibration, operating and environmental conditions.

4.2.4 In general, piping penetrations through the chamber are to have isolating valves on both sides.

4.2.5 Materials used in the construction of hyperbaric evacuation systems are to be suitable for their intended use.

4.2.6 Components in the hyperbaric evacuation system are to be so designed, constructed and arranged as to permit easy inspection, maintenance, cleaning and, where appropriate, disinfection.

4.2.7 Component parts of a hyperbaric evacuation system are to be designed, constructed and tested in accordance with recognized national/ international standards acceptable to the Administration/ IRS.

4.2.8 The hyperbaric evacuation system is to be provided with the necessary control equipment to ensure its safe operation and the well-being of the divers.

4.2.9 Special arrangements and instructions are to be provided externally to enable the hyperbaric evacuation unit to be recovered safely. The instructions are to be located where they will be legible when the hyperbaric evacuation unit is floating.

4.2.10 Hyperbaric evacuation systems are not to be located in hazardous areas of Zone 0 or Zone 1. Other hazardous areas and high fire risk areas are to be avoided as far as is reasonably practicable.

4.2.11 Hyperbaric Evacuation Unit

.1 The hyperbaric evacuation unit is to be designed for the rescue of all divers in the diving system at the maximum operating depth.

.2 The compression chamber is to provide a suitable environment and adequate facilities, including, where appropriate, seat belts, for the maximum number of persons for which the unit is designed.

.3 The seating or other arrangements provided are to be designed to provide an adequate degree of protection to the divers from impact collisions during launch and while the unit is afloat.

.4 Where the chamber is intended to be occupied for more than 12 hours, arrangements for the collection or discharge of human waste are to be provided. The discharge arrangements are to be fitted with suitable interlocks.

.5 The means provided for access into the compression chamber is to allow safe access to or from the surface compression chambers. Interlocks are to be provided to prevent the inadvertent release of the hyperbaric evacuation unit from the surface compression chamber while the access trunk is pressurized.

.6 The mating flange is to be adequately protected from damage at all times including during the launch and recovery stages.

.7 Arrangements are to be provided to enable an unconscious diver to be taken into the unit.

.8 Compression chamber doors are to be so designed as to prevent accidental opening while pressurized.

.9 All doors are to be so designed that, where fitted, the locking mechanisms can be operated from both sides.

.10 Arrangements are to be provided to allow the occupants to be observed. If viewports are provided they are to be situated so that risk of damage is minimized.

.11 Where it is intended to carry out decompression of the divers after hyperbaric evacuation in another surface compression chamber, then suitability of the mating arrangements on that surface compression chamber are to be specially considered. A suitable adapter and clamping arrangements are to be provided, where necessary,

.12 A medical lock is to be provided and be so designed as to prevent accidental opening while the compression chamber is pressurized. Interlock arrangements are to be provided for this where necessary. The dimensions of the medical lock are to be adequate to enable essential supplies, including scrubber canisters, to be transferred into the compression chamber, and be of such dimensions as to minimize the loss of gas when the lock is being used.

4.2.12 Stability and Buoyancy

.1 Hyperbaric evacuation units designed to float are be provided with adequate stability for all envisaged operating and environmental conditions and be self-righting. In determining the degree of stability to be provided, consideration is to be given to the adverse effects of large righting moments on the divers.

.2 The effect which equipment and rescue personnel, required to be placed on the top of the system to carry out a recovery from the sea, may have on the stability of the hyperbaric evacuation unit, are also to be taken into account.

.3 Towing attachment points are to be so situated that there is no likelihood of the hyperbaric evacuation unit being capsized as a result of the direction of the tow line. Where towing harnesses are provided they are to be lightly clipped or secured to the unit and, so far as is possible, be free from snagging when pulled free.

.4 Hyperbaric evacuation units designed to float are to have sufficient reserves of buoyancy to enable the necessary rescue crew and equipment to be carried.

.5 Where hyperbaric evacuation units are designed to be placed on board a rescue vessel, attachment points are to be provided on the unit to enable it to be secured to the deck.

.6 Hyperbaric evacuation units on ships required to be provided with fire-protected lifeboats are to be provided with a similar degree of fire protection.

4.2.13 Life Support Systems

.1 Means are to be provided to maintain all the occupants in thermal balance and in a safe and breathable atmosphere for all environmental conditions envisaged - air temperature, sea temperature and humidity - and with the maximum and minimum number of divers likely to be carried.

.2 In determining the duration and amount of life support necessary, consideration is to be given to the geographical and environmental conditions, the oxygen and gas consumption and carbon dioxide generation under such conditions, the heat input or removal and the emergency services that may be available for the decompression of the divers.

.3 Gas losses as a result of using toilet facilities which discharge to outside the hyperbaric evacuation unit and medical lock operation are to be taken into account in determining the amount of gases required. The effects of hypothermia are to be considered and the effectiveness of the arrangements provided are to be established as far as is reasonable and practicable under all conditions envisaged. However, in no such case should the duration of the unit's autonomous life-support endurance be less than 72 hours.

.4 In addition to any controls and equipment fitted externally, compression chambers are to be provided with adequate controls within for supplying and maintaining the appropriate breathing mixtures to the occupants, at any depth down to the maximum operating depth.

.5 The persons operating the chamber, whether they are within or outside it, are to be provided with adequate controls to provide life support. As far as practicable, the controls are to be capable of operation without the person who operates them having to remove his/ her seat belt.

.6 Two separate distribution systems are to be provided for supplying oxygen to the compression chamber.

.7 Components in the system are to be suitable for oxygen service.

.8 Adequate equipment is to be provided and be suitably situated to maintain O_2 and CO_2 levels and thermal balance within acceptable limits while the life-support equipment is operating.

.9 In addition to any instrumentation necessary outside the compression chamber, suitable instrumentation is to be provided within the chamber for monitoring the partial pressures of O_2 and CO_2. The same are to be capable of operation for the duration of the available life support period.

.10 Where it is intended that divers may be decompressed within the hyperbaric evacuation unit, provision is to be made for the necessary equipment and gases, including therapeutic mixtures, to enable the decompression process to be carried out safely.

.11 An adequate supply of food and water is to be provided within the hyperbaric evacuation unit. In determining, in particular, the amount of water to be provided, consideration is to be given to the area of operation and the environmental conditions envisaged.

.12 A breathing system is to be provided with a sufficient number of masks for all the occupants under pressure.

.13 Provision is to be made external to the hyperbaric evacuation unit, and in a readily accessible place, for the connection of emergency hot or cold water and breathing therapeutic mixture. The dimensions of the connections provided are to be as follows:

- 3/4 in. NPT (female) - hot or cold water
- 1/2 in. NPT (female) - breathing mixture

The connections are to be clearly and permanently marked and be suitably protected.

.14 In hyperbaric evacuation units designed to pass through fires; the breathing gas bottles and piping systems and other essential equipment are to be adequately protected.

.15 In addition, thermal insulation is to be nontoxic and suitable for this purpose.

.16 First-aid equipment, sickness bags, paper towels, waste disposal bags and all necessary operational instructions for equipment within the compression chamber are to be available within the chamber, on board the parent vessel and ashore.

4.2.14 Fire Protection and Extinction

.1 Materials used in the construction and installation are to be non- combustible and nontoxic, as far as practicable.

.2 A fire-extinguishing system is to be provided in the hyperbaric evacuation unit which is to be suitable for exposure to all depths down to the maximum operating depth.

.3 In hyperbaric evacuation units that are designed to float and may be used to transport divers through fires, consideration is to be given, where practicable, to providing an external water spray system for cooling purposes (see 2.11.6).

4.2.15 Electrical Arrangements

.1 Electrical equipment within the compression chamber is to be designed for hyperbaric use, high humidity levels and marine application. They are to be designed to minimize the risk of electrical capacity depletion as a result of a fault, fire or explosion, electric shock, the emission of toxic gases and galvanic action.

.2 Power supplies required for the operation of life-support systems and other essential services are to be sufficient for the life-support duration.

.3 The battery charging arrangements are to be designed to prevent overcharging under normal or fault conditions. The battery storage compartment is to be provided with means to prevent over-pressurization and any gas released is to be vented to a safe place.

.4 Each compression chamber is to be provided with a source of lighting sufficient for the life-support time and of sufficient luminosity to allow the occupants to read gauges and operate essential systems within the chamber.

4.2.16 Launch and Recovery of Hyperbaric Evacuation Units

.1 Means are to be provided for the safe and timely evacuation and recovery of the unit and due consideration is to be given to the environmental and operating conditions and the dynamic snatch and impact loadings that may be encountered.

.2 Where appropriate, the increased loadings due to water entrainment are to be considered.

.3 Where the primary means of launching depends on the ship's main power supply, then a secondary and independent launching arrangement is to be provided.

.4 If the power to the handling system fails, brakes are to be engaged automatically. The brake is to be provided with manual means of release.

.5 The launching arrangements provided are to be designed to ensure easy connection or disconnection of the hyperbaric evacuation unit from the surface compression chamber and for the transportation and removal of the unit from the ship under the same conditions of trim and list as those for the ship's other survival craft.

.6 Where a power-actuated system is used for the connection or disconnection of the hyperbaric evacuation unit and the surface compression chamber; a manual or stored power means of connection or disconnection is also to be provided.

.7 The means provided for release of the falls or lift wire after the unit is afloat is to provide for easy disconnection, particular attention being given to units not provided with an attendant crew.

.8 Where the hyperbaric evacuation unit is designed to be recovered from the sea, or from a ship in a seaway, consideration is to be given to the mode of recovery.

.9 Adequate equipment is to be provided on the unit to enable safe recovery. Permanently marked, clear instructions are to be provided adjacent to the lifting equipment as to the correct method for recovery, including the total weight of the hyperbaric evacuation unit.

.10 The effect of entrained water and any bilge water which may affect the total weight to be lifted by the recovery vessel is to be considered. Absorption of the dynamic snatch loads imposed during the recovery of the hyperbaric evacuation unit from the sea is also to be considered.

4.2.17 Communication and Locating Devices

.1 If breathing mixtures containing helium or hydrogen are used, a self-contained primary communication system fitted with an unscrambler device is to be arranged for direct two-way communication between the divers and those outside the compression chamber. A secondary communication system is also to be provided.

.2 In addition to the communication system referred to in 4.2.17.1, a standard bell emergency communication tapping code is to be provided, as indicated in Table 3.2.12.6. Copies of the tapping code are to be permanently displayed inside and outside the hyperbaric evacuation unit.

.3 Hyperbaric evacuation units designed to be waterborne are to be provided with a strobe light and radar reflector.

.4 Hyperbaric evacuation units designed to be placed on the sea-bed to await independent recovery are to be provided with an acoustic transponder. The transponder is to be suitable for operation with a diver-held interrogator-receiver which will be retained on board the parent ship. The equipment provided is to meet the requirements indicated in 3.2.12.5.

4.3 Marking and Information to be provided on Hyperbaric Evacuation Units

4.3.1 Dedicated hyperbaric evacuation units are to be coloured orange and be provided with retro-reflective material to assist in their location during hours of darkness.

4.3.2 Each hyperbaric evacuation unit designed to be waterborne is to be marked with at least three identical signs as shown in Fig 4.3.2. One of these markings is to be on top of the unit and be clearly visible from the air. The other two are to be mounted vertically on both sides and as high as possible and should be capable of being seen while the unit is afloat.

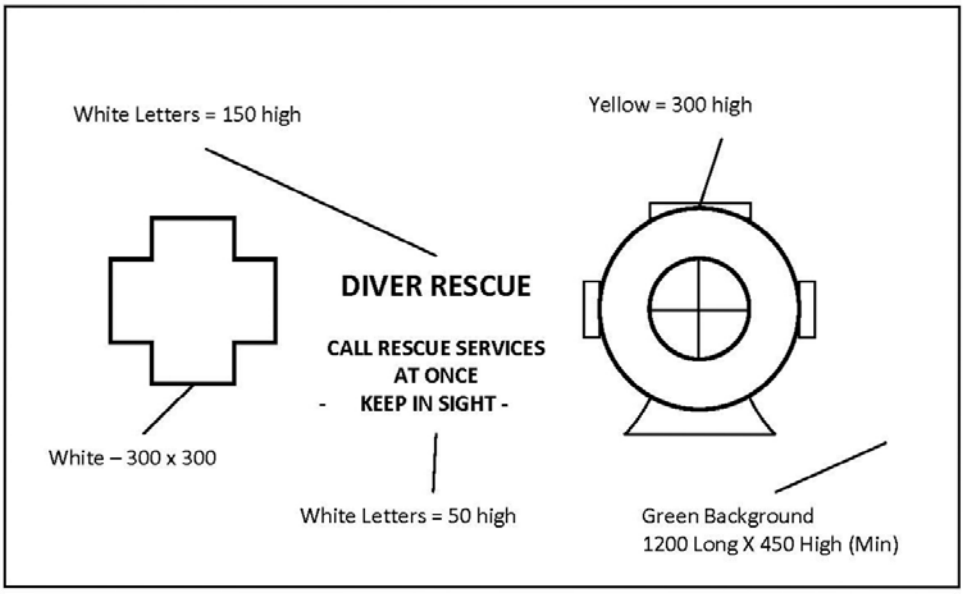


Fig 4.3.2 : Marking on Hyperbaric Evacuation Units

4.3.3 Whilst the unit is afloat, the following instructions and equipment, as applicable, are to be clearly visible and kept readily available:

- Towing arrangements and buoyant towline;
- All external connections, particularly for the provision of emergency gas, hot/ cold water and communications;
- Maximum gross weight of unit in air;
- Lifting points;
- Name of parent ship and port of registration;
- Emergency contact telephone and fax numbers.

4.3.4 Warning Instructions

.1 Where appropriate, the following instructions are to be permanently displayed on every hyperbaric evacuation unit in two separate locations so as to be clearly visible while the unit is afloat:

.1 Unless specialized diving assistance is available

- Do not touch any valves or other controls;
- Do not try to get occupants out;
- Do not connect any gas, air, water or other supplies;
- Do not attempt to give food, drinks or medical supplies to the occupants; and
- Do not open any hatches.

4.4 Surveys of Hyperbaric Evacuation Systems

4.4.1 General/ Initial Survey Requirements

.1 Statutory requirements of state/ national authorities/ flag administrations are to be kept in mind, whilst approving and surveying HES.

.2 The interface between the HES and the installed diving system is to be examined carefully so that the HES does not become a hazard to the diving system operations.

.3 HES are connected to the diving system and are to be surveyed in the same manner as the main diving system. Corrosion on the chamber exterior is to be examined carefully due to high humidity levels.

.4 Apart from the drawings/ documents being examined (as listed in 1.5), the following need to be specifically examined:

- Sufficient Built in Breathing Systems (BIBS) fitted and functional;
- BIBS overboard dump fitted and functional;
- locking mechanism fitted and functional;
- doors can be opened from both sides;
- doors can be secured "open";
- equalization can be done if appropriate;
- seatbelts for the maximum complement of divers provided;
- lighting fitted and functional;
- toilet provided;
- protective headgear provided
- recovery system available
- falls of sufficient length, where applicable.

.5 Examine if the HES is marked as per requirements, stipulated in 4.3 and a copy of the tapping code is placed inside and outside the chamber, as stipulated in 3.2.12.6.

.6 Examine, if arrangements to lift an injured diver are provided

.7 Examine, if the HEU has undergone a stability test to ensure that it floats at correct orientation. Launch the HEU and examine if the free-floating unit is positively buoyant, when fully equipped and manned.

.8 In installations where the saturation diving system is mounted on an offshore production and/ or drilling platform, examine if the HES has some form of propulsion or other suitable method of rapid clearance from the installation.

.9 Confirm, that the HES is able to accommodate the maximum number of divers (as per design) that may be under pressure

.10 Confirm, that the HES is included in the Planned Maintenance System, as per the Operation Manual and contingency plans are also available

.11 Confirm that written procedures for launching of the HES including responsibilities of operators, manning of stations, etc. are available.

.12 Examine, if first aid kit, (as per scale and applicable requirements) is provided.

4.4.2 Periodical Surveys

.1 Periodical surveys of HES are to be carried out as per the requirements in Pt. 1, Ch.2, Sec. 18, 18.5.2.

End of Chapter

Chapter 27

Helicopter Decks

Contents

Section

Section 1

General

1.1 Application

1.1.1 The requirements of this Chapter apply to vessels with erected landing platform for helicopters or a landing area arranged directly on weather deck or top of deckhouse.

1.1.2 Where the landing area forms part of a weather or erection deck, the scantlings are also to comply with the requirements given in Pt.3, Ch.9 for decks in the same position.

1.1.3 Vessels built in compliance with the above requirements will be eligible to be assigned class notation "HELDK".

1.2 Arrangements

1.2.1 The landing area is to be sufficiently large to allow for the landing and manoeuvring of the helicopter, and is to be approached by a clear landing and take-off sector, the extent of which is to comply with the applicable regulations of National or other authorities.

1.2.2 The landing area is to be free of any projections above the level of the deck. Projections in the zone surrounding the landing area are to be kept below the heights permitted by the regulations.

1.2.3 Suitable arrangements are to be made to minimize the risk of personnel or machinery sliding off the landing area. A non-slip surface and anchoring devices are to be provided.

1.2.4 Arrangements are to be made for drainage of the platform, including drainage of spilt fuel.

1.3 Documentation

1.3.1 Plans showing scantlings and arrangement of the structure and particulars of the materials of construction are to be submitted for approval. The type, size, maximum total weight of the helicopter and its fore-and-aft distribution is to be indicated on the plans.

1.4 Materials

1.4.1 The grades of steel and aluminium materials are to be in compliance with the requirements to hull materials given in Pt.3, Ch.2.

1.4.2 Where aluminium alloy platforms are connected to steel structures, detail of the arrangements in way of the connections including those to prevent galvanic corrosion are to be submitted for approval.

Section 2

Design Loads

2.1 General

2.1.1 The scantlings of each structural element is to be based on the most unfavourable of the following loading conditions:

- Extreme functional loads (landing) together with hull still water loads.
- Extreme environmental loads acting on hull, helicopter deck and helicopter in stowed transit position, if applicable, together with hull still water loads. The effect of icing is to be included for erected structures.

2.2 Landing forces

2.2.1 The total vertical force from the helicopter during landing is to be taken not less than:

$$P = 2\ g_o\ M_H\ .\ 10^3\ [N]$$

where,

M_H = the maximum take-off mass in tonnes of helicopter.

Landing force (P_w) acting on a wheel or a group of wheels, is to be obtained by considering that the total force P is distributed on the helicopter's landing gear in the same manner as when the helicopter is resting on a horizontal surface and the helicopter's centre of gravity is in its normal position in relation to the landing gear.

2.2.2 A horizontal sliding force of $0.5\ g_o\ M_H\ 10^3$ [N] may have to be taken into account for hatch covers and bolted platforms.

2.3 Gravity and inertia forces (due to ship motions and accelerations)

2.3.1 The static and dynamic design forces caused by the platform structure itself and, if applicable, by the helicopter in stowed position are to be considered. The effect of icing is to be additionally considered, if applicable.

2.4 Sea and weather loads

2.4.1 The sea pressure for superstructure deck and top of houses is to be taken in accordance with Pt.3, Ch.4. For elevated platforms with free water passage below, the sea pressure may be taken as:

p = 0.0075 [N/mm^2] forward of 0.15 L from FP.

= 0.0025 [N/mm^2] aft of 0.15 L from FP.

2.4.2 For structures where wind suction forces may be of importance, (e.g. bolted platforms), wind lift forces are to be taken into account by:

$$P_L = 1.2\ A\ .\ 10^3\ [N]$$

where,

A = deck area [m^2] of the platform.

Section 3

Structural Requirements

3.1 Deck plating and stiffening

3.1.1 Decks for helicopters supported on wheels with pneumatic tyres are to have scantlings in accordance with the following:

Thickness of deck plating is not to be less than:

$$t = f\,(s+1000)\,\sqrt{P_w}\,\sqrt{k}\,10^{-5} + t_c \text{ [mm]}$$

where,

f = 1.90 for separate platforms of steel or aluminium

= 2.05 for weatherdecks, in general

= 2.20 for longitudinally framed strength deck and for weather deck hatch covers of steel or aluminium

= 2.85 for transversely framed strength deck

s = stiffener spacing [mm]

P_w = Landing force [N], acting on the wheel or group of wheels considered as per 2.2.1

k = the material factor as per Pt.3, Ch.2, Sec.1.2 for steel

$= \dfrac{235}{\sigma_a}$ for aluminium alloys

σ_a = 0.2% proof stress or 70% of the ultimate strength of the aluminium alloy material, whichever is lesser [N/mm^2]

t_c = 2.0 [mm] for steel

= 1.0 [mm] for aluminium.

3.1.2 Section modulus of deck stiffeners is not to be less than:

$$Z = \frac{BM}{\sigma}\ [\mathrm{cm}^3]$$

BM = bending moment [N-m] for the most unfavourable location of landing forces (point loads), assuming 50% fixity at ends.

σ = 180/k [N/mm^2] in general; to be reduced by still water longitudinal hull girder stress for strength deck longitudinals.

= 160/k [N/mm^2] for weather deck hatch covers.

3.1.3 Each stiffener to girder connection is to have a shear area not less than:

$$A = 1.25\, P_w\, k\, 10^{-4}\ [\mathrm{cm}^2].$$

3.1.4 Decks for helicopters supported on tubular skids are to have scantlings in accordance with the following:

- Thickness of deck plating is to be not less than that obtained using the formula in 3.1.1 taking P_w as 0.9P, where P is the total landing force as per 2.2.1.

- Section modulus of stiffeners is to be as per 3.1.2.

3.2 Girders and supporting structures of separate platforms

3.2.1 The scantlings are normally to be based on the following allowable stresses:

Normal stress, $\sigma \le 160/k$ [N/mm^2]

Shear stress, $\tau \le 90/k$ [N/mm^2].

3.2.2 The helideck supporting members are to satisfy the buckling criteria as per Pt.3, Ch.3, Sec.6.

3.2.3 The critical buckling stress of plating acting as girder flange is to satisfy the buckling criteria as per Pt.3, Ch.3, Sec.6 taking η as 0.67.

Tripping brackets and local stiffening of plating are to be provided where necessary.

3.2.4 In the case of landing on a hatch cover section which is underlying in the packing joint, the strength and spacing of cleats must be sufficient to keep the connection intact and weathertight.

End of Chapter

Chapter 28

Single Point Mooring

Contents

Section

Section 1

General

1.1 Application

1.1.1 The requirement of this chapter applies to ships fitted with standardized equipment complying with the recommendations of the Oil Companies International Marine Forum (OCIMF) for mooring at single point mooring or single buoy mooring terminals. Vessels complying with these requirements will be assigned class notation 'SPM' as per Pt.1, Ch.1 of Rules.

1.1.2 Where some components of mooring equipment are used for both single point mooring and for the bow emergency towing arrangements, the requirements for emergency towing arrangements (specified in Pt.5, Ch.2) are also to be complied with.

1.1.3 Where the mooring components are to be type approved, the requirements given in 'Certification Scheme for Type Approval of Products' are also to be complied with.

1.2 Documentation for approval

1.2.1 The following plans are to be submitted to IRS for approval:

- General layout of the associated equipment at the forecastle/fore deck.

- Construction drawing of the bow chain stoppers/Smit type brackets, bow fairleads and pedestal roller fairleads, together with material specifications and relevant calculations.

- Plans of the supporting structure in way of chain stoppers/Smit type brackets, fairleads, roller pedestals, winches and capstans.

- Arrangements for pull back from tugs, wherever applicable.

1.3 Documentation for information

1.3.1 The following documentation is to be submitted for information.

- Specifications of winches or capstans giving the continuous duty pull and brake holding capacity.

- DWT, in tonnes, of the ship at summer load line.

Section 2

General Arrangement

2.1 General

2.1.1 Suitable equipment and arrangements are to be provided near the bow of the vessel for heaving onboard a standard chafing chain of 76 [mm] diameter using a pick-up rope and for securing the chain to the strong point.

2.1.2 The strongpoint is to be a chain cable stopper / Smit type bracket.

2.1.3 A typical schematic layout of the forecastle is shown in Fig.2.1.3 for reference.

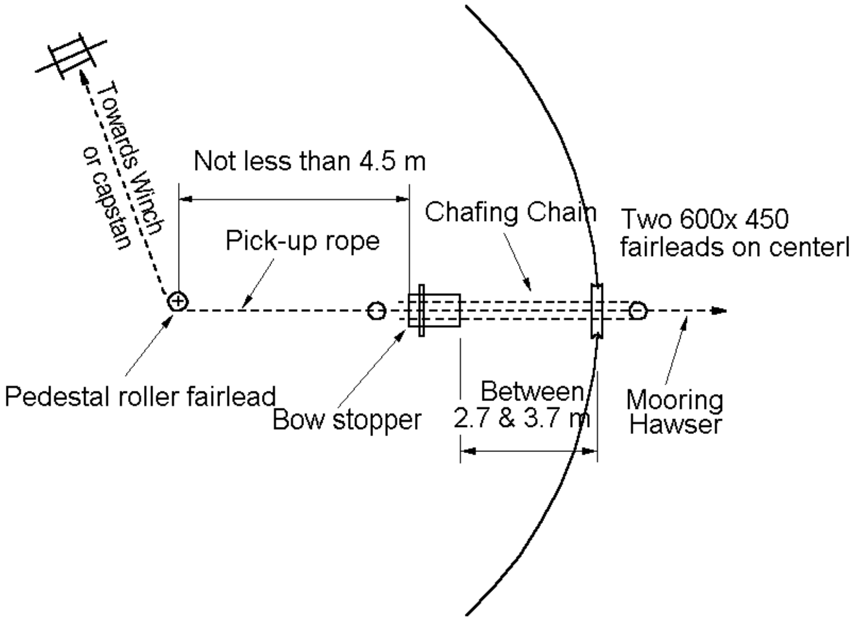
2.1.4 Where tugs are used for pull back, suitable arrangements for connecting the lines from tugs are to be provided.

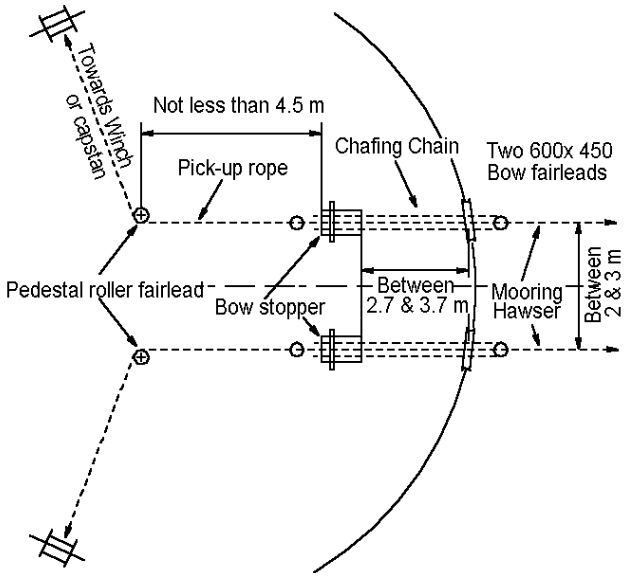
2.2 Equipment components

2.2.1 The equipment for mooring is to generally consist of the following components :

- bow chain stopper or Smit type bracket;
- bow fairlead;
- pedestal roller fairlead;
- winch or capstan.

DWT ≤ 150000 t





DWT > 150000 t

Fig.2.1.3 : Forecastle schematic layout

Section 3

Mooring Components

3.1 General

3.1.1 The ship is to be equipped with bow chain stoppers or Smit type brackets complying with the requirements in Table 3.1.1 and suitable for a standard chafing chain of 76 [mm] in diameter.

The requirements for materials, manufacture, testing and certification of the 76 [mm] chafing chain are given in Part 2, Chapter 10, Section 5.15 of the Rules. Grade R3 and R4, indicated in Part 2, chapter 10 are to be used corresponding to Safe working load of 200 [t] and 250 [t] respectively. (See Table 3.1.1).

Note : Chafing chains are not required to be part of ship's equipment when supplied by the SPM terminal operator.

3.1.2 Where the safe working loads are increased to take into account the local environmental conditions, the same is to be clearly stated on plans submitted for approval.

Table 3.1.1 : Required Number and SWL of Chain stoppers/Smit Type Brackets

Deadweight [t]	Number	Safe working load (SWL) [t] (kN)
DWT ≤ 150000	1	200 (1961)
150000 < DWT ≤ 350000	2	200 (1961)
DWT > 350000	2	250 (2452)

3.1.3 The scantlings of all parts of bow chain stopper, Smit Type Brackets and bow fairleads are to be in accordance with the strength criteria given in Sec.5.

3.1.4 The bow chain stoppers, Smit type bracket and bow fairleads are to be made of fabricated steel, steel castings or forgings complying with relevant requirements given in Pt.2, Chapters 3, 4 and 5 respectively.

Use of spheroidal graphite (SG) iron casting may be accepted for the main framing of the chain stopper provided that:

- The part concerned is not intended to be a component part of a welded assembly.

- The SG iron casting is of ferritic structure with an elongation not less than 12%.

- The yield stress at 0.2% strain is to be measured and certified.

– The internal structure of the component is to be inspected by means of non-destructive examination.

The material used for the stopping device (pawl or hinged bar in chain stoppers and the pin in Smit Type Brackets) is to have mechanical properties similar to that of a Grade CC3 chain cable or better.

3.2 Bow chain stopper

3.2.1 The stoppers are to be capable of securing the common stud links of the chafing chain cable when the stopping device (chain engaging pawl or bar) is in the closed position and of freely passing the chain cable and its associated fittings when the stopping device is in the open position.

3.2.2 Chain stoppers may be of the hinged bar type or of pawl (tongue) type or of other equivalent design.

Typical arrangements of chain stoppers are shown in Fig.3.2.2.

3.2.3 The stopping device (chain engaging pawl or bar) of the chain stopper is to be so arranged as to prevent it from gradually working to the open position from the closed position which would release the chafing chain and allow it to pay out.

Stopping devices are to be easy and safe to operate and are to be properly secured in the open position.

3.2.4 Chain stoppers are to be located between 2.7 [m] and 3.7 [m] inboard from the bow fairleads (See Fig.2.1.3).

When positioning, due consideration is to be given to the correct alignment of the stopper relative to the direct lead between bow fairlead and pedestal roller fairlead.

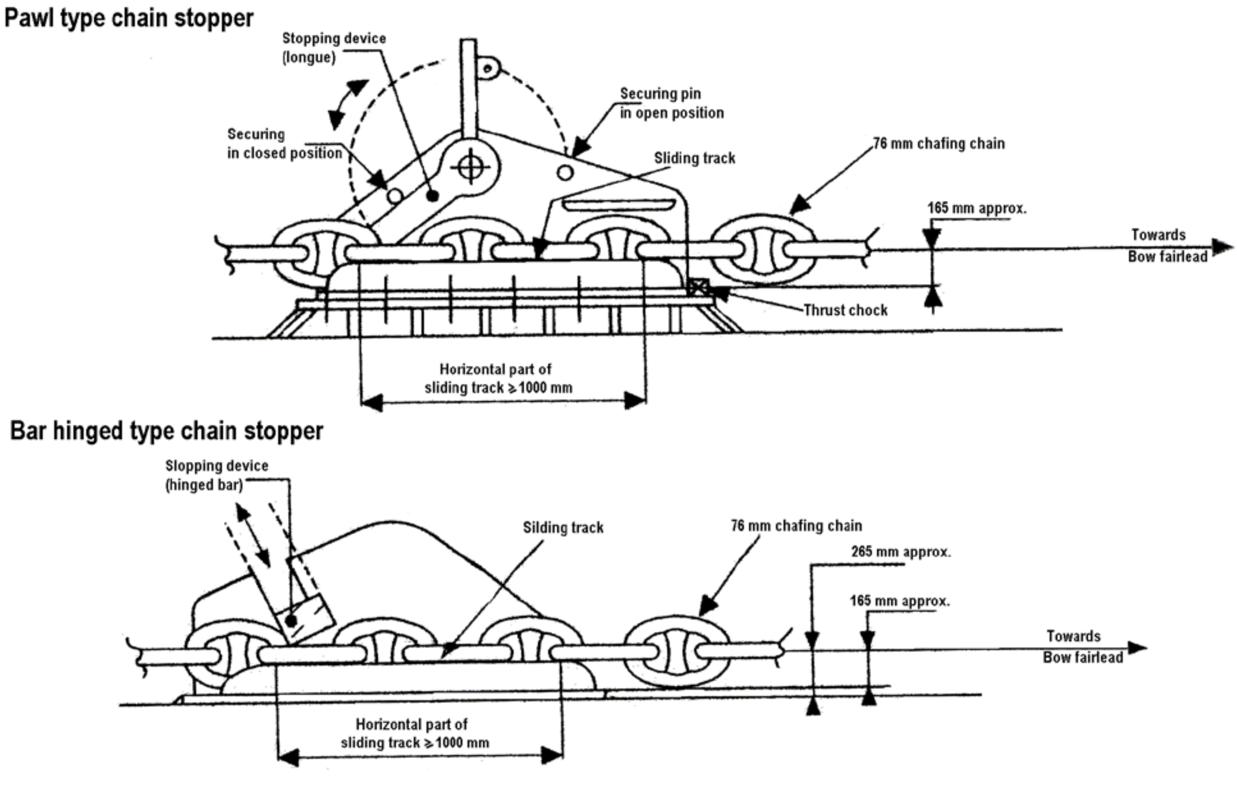


Fig.3.2.2 : Typical bow chain stoppers

3.2.5 Stopper support structures are to be trimmed to compensate for any camber and/or sheer of the deck. The leading edge of the stopper base plate is to be faired to allow for the unimpeded entry of the chafing chain into the stopper.

3.2.6 Where the chain stopper is bolted to a seating welded to the deck, the bolts are to be relieved from shear force by efficient thrust chocks capable of withstanding horizontal force equal 1.5 times the required working load satisfying the strength criteria specified in Sec.5.

Mechanical properties of bolt material are to be not less than Grade 8.8 of ISO standard No.898/1.

3.3 Smit Type Brackets

3.3.1 Where fitted, Smit type brackets (Fig.3.3.1) are to be located between 2.7 [m] and 3.7 [m] aft of the bow fairlead and should be positioned so as to give correct alignment with the bow fairlead and pedestal fairlead or drum end of the winch or capstan. (See Fig.2.1.3).

3.3.2 To facilitate connection to the terminal equipment it is recommended that each Smit type bracket be provided with a length of chain cable comprising a pear link, an open link and a special shackle, see Fig.3.3.1. The safe working load is to be as given in Table 3.1.1 for bow stoppers.

3.3.3 Adjacent to each Smit type bracket a lug with a recommended safe working load of 490 [kN] (50 tonnes) is to be attached to the doubler plate.

The lug is to be provided with a hole of sufficient size to accept the pin of a 490 [kN] (50 tonnes) SWL shackle and is to be used as a securing point for holding the chain.

3.4 Bow fairleads

3.4.1 One bow fairlead is to be fitted for each bow chain stopper or Smit type bracket (See Fig.2.1.3).

3.4.2 For ships of more than 150000 t DWT, where two bow fairleads are required, the fairleads are to be spaced 2.0 [m] centre to centre apart, if practicable and in no case be more than 3.0 [m] apart.

For ships of 150000 t DWT or less for which only one bow fairlead is required (See Table 3.1.1), it is in general to be fitted on the centreline.

3.4.3 Fairleads are normally of a closed type (as Panama chocks) and are to have an opening large enough to pass the largest portion of the chafing gear, pick-up rope and associated fittings.

For this purpose, the inner dimensions of the bow fairlead openings are to be at least 600 [mm] in width and 450 [mm] in height.

3.4.4 Fairleads are to be oval or round in shape.

The lips of the fairleads are to be suitably faired in order to prevent the chafing chain from fouling on the lower lip when heaving inboard.

The ratio of the diameter of the bearing surface of the fairlead to the diameter of the chafing chain, is to be not less than 7 to 1.

3.4.5 The fairleads are to be located as close as possible to the deck and, in any case, in such a position that the chafing chain is approximately parallel to the deck when it is under strain between the chain stopper and the fairlead.

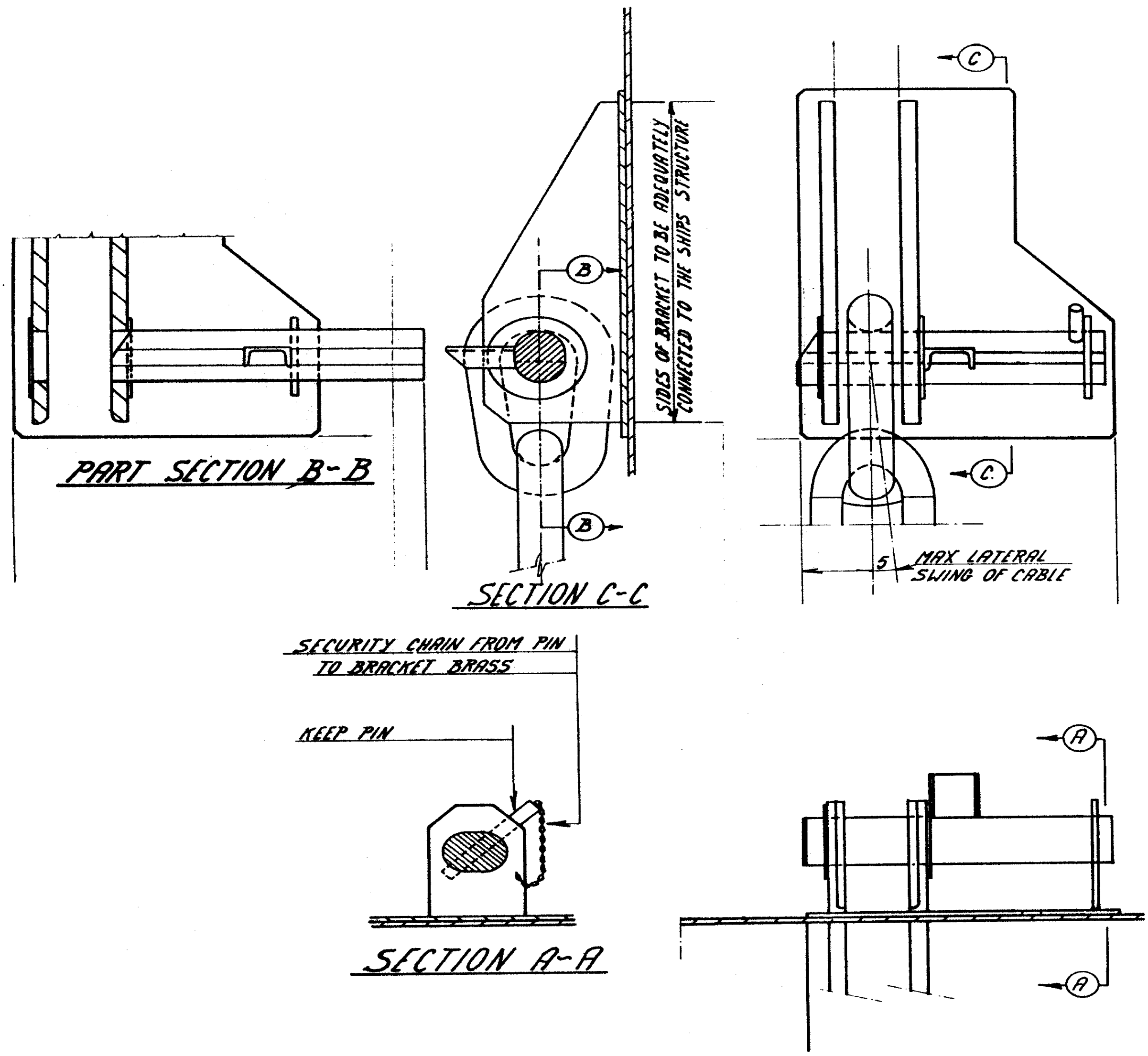


Fig.3.3.1 : Smit Type Bracket

3.5 Pedestal roller fairleads

3.5.1 Pedestal roller fairleads are to be so positioned as to provide a direct lead to bow chain stopper and bow fairlead. (See Fig.2.1.3).

They are to be fitted not less than 4.5 [m] behind the bow chain stopper.

3.5.2 The pedestal roller fairleads are to be capable to withstand a horizontal force equal to:

- the resultant force due to an assumed pull of 225 [kN] in the pick-up rope; or
- 225 [kN], whichever is greater.

Stresses generated by this horizontal force are not to exceed those given in 5.2.

3.5.3 It is recommended that the fairlead roller is to have a diameter not less than 7 times the diameter of the pick-up rope.

3.6 Winches or capstans

3.6.1 Winches or capstans used to handle the mooring gear are to be capable of exerting a continuous duty pull of not less than 150 [kN] and withstanding a braking pull of not less than 225 [kN].

3.6.2 Winch storage drums used to stow the pick-up rope, are to be of sufficient size to accommodate 150 [m] of polypropylene rope of 80 [mm] diameter.

Section 4

Supporting Hull Structures

4.1 General

4.1.1 The bulwark plating and stays are to be suitably reinforced in the region of the fairleads.

4.1.2 Deck structures in way of bow chain stoppers, including deck seatings and deck connections, are to be suitably reinforced to comply with the strength criteria specified in Sec.5.

4.1.3 The deck structures in way of the pedestal roller fairleads and in way of winches or capstans as well as the deck connections are to be reinforced to withstand, respectively, the horizontal force defined in 3.5.2 or the braking pull defined in 3.6.1 and to meet the strength criteria specified in Sec.5.

4.1.4 The deck plating in way of the mooring capacity mentioned in 4.1.2 and 4.1.3 is to be increased by means of suitable insert plates.

4.1.5 Main welds of the bow chain stoppers with the hull structure are to be inspected by means of non-destructive examination for their complete length.

Section 5

Strength Criteria

5.1 Design loads

5.1.1 The bow chain stopper, Smit type bracket and the bow fairlead are to be designed considering a horizontal chafing chain tension equal to 1.5 times the SWL given in Table 2.1.1.

5.2 Allowable stresses

5.2.1 The equivalent stress, σ_e, induced by the load given in 5.1.1 is not to exceed 0.67 σ_y or 0.4 σ_u whichever is lesser.

where,

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2}$$

σ = tensile stress
τ = shear stress
σ_y = Minimum yield stress [N/mm^2], of the component material
σ_u = Tensile strength [N/mm^2], of the component material.

End of Chapter

Chapter 29

Vapour Control Systems

Contents

Section

Section 1

General Requirements

1.1 Application

1.1.1 The requirements given in this chapter apply to systems for control of vapour emissions from cargo tanks on ships which are assigned class Notation 'OIL TANKER' or 'CHEMICAL TANKER' or 'ORE OR OIL CARRIER' or 'OIL OR BULK CARRIER'.

1.2 Class notations

1.2.1 Vessels complying with the requirements given in this chapter except those given in 3.2.2 and Section 4, will be eligible to be assigned class notation 'VCS1'.

Compliance with these requirements is considered to meet the requirements of IMO MSC/Circ.585.

1.2.2 Vessels complying with all the requirements in this chapter and the requirements in United States Coast Guard requirement given in the regulation CFR46 Part 39 - "Vapour Control Systems" will be eligible to be assigned class notation 'VCS2'.

1.3 Definitions

1.3.1 '*Diluted*' means the condition in which the concentration of a flammable gas in a flammable gas/air mixture is less than 50% of the lower explosive limit of the gas.

1.3.2 '*Enriched*' means the condition in which the concentration of a flammable gas in a flammable gas/air mixture is not less than 150% of the upper explosive limit of the gas. When flammable gases are mixed to achieve an enriched condition, the upper explosive limit of the flammable gas mixture shall be used.

1.3.3 '*Flammable cargoes*' means cargoes of crude oil, petroleum products and chemicals having a flashpoint not exceeding 60°C (closed cup test), as determined by an approved flashpoint apparatus and a Reid vapour pressure which is below atmospheric pressure and other liquid products having a similar fire hazard.

1.3.4 '*Inerted*' means the condition in which the oxygen content in a flammable gas/air mixture is 8% or less by volume.

1.3.5 '*Independent*' as applied to two systems means that one system will operate with a failure of any part of the other system except power sources and electrical feeder panels.

1.3.6 '*Maximum allowable transfer rate'* means the maximum volumetric rate at which a tanker may receive cargo or ballast.

1.3.7 '*Tanker vapour connection'* means the point in a tanker's fixed vapour collection system where it connects to a vapour collection hose or arm.

1.3.8 '*Terminal vapour connection'* means the point in a terminal's vapour collection system where it connects to a vapour collection hose or a vapour collection arm.

1.3.9 '*Vapour balancing'* means the transfer of vapour displaced from the tank of a tanker receiving cargo into a tank of a facility delivering cargo via a vapour collection system.

1.3.10 '*Vapour collection system'* means an arrangement of piping and hoses used to collect vapour emitted from a tanker's cargo tanks and transport the vapour to a vapour processing unit.

1.3.11 '*Vapour destruction unit'* means a vapour processing unit that destroys cargo vapour by a means such as incineration.

1.3.12 '*Vapour dispersion system'* means a vapour processing unit which releases cargo vapour to the atmosphere through a venting system not located on the tanker being loaded or ballasted.

1.3.13 '*Vapour emission control system'* means an arrangement of piping and hoses used to control vapour emissions collected from a tanker and includes the vapour collection system and the vapour processing unit.

1.3.14 '*Vapour processing unit'* means the components of a vapour control system that recovers, destroys or disperses vapour collected from a tanker.

1.3.15 '*Vapour recovery unit'* means a vapour processing unit that recovers cargo vapour by a non-destructive means such as lean oil absorption, carbon bed adsorption or refrigeration.

1.3.16 '*Service ship'* means a ship which receives and transports liquid cargoes between a facility and another ship and vice versa.

1.3.17 '*Topping-off operation'* means operation of transfer of liquid cargo from a service ship to another ship in order to load the receiving ship at a deeper draft.

1.4 Documentation

1.4.1 The following plans and particulars are to be submitted:

a) A schematic drawing of the vapour piping systems giving information about material, dimensions, pressure rating etc. Details about penetrations, joining etc. are also to be submitted.

b) A schematic drawing of the gauging and overfill protection equipment showing:

- Working principle
- Independent control
- Location of electrical equipment in gas dangerous area
- Single line diagram of intrinsically safe equipment
- Use of explosion protected equipment with reference drawing together with certificates.

c) A schematic drawing of the venting system (Inert Gas System if relevant) including necessary data for verifying venting capacities of the P/V valves. Pressure monitoring and alarm system to be documented including wiring diagrams, cable penetrations and connections etc.

d) Pressure drop calculations comparing cargo transfer rate to pressure drop from the farthest tank to the vapour connection, including any hoses used. Calculation to be made for each cargo handled at the maximum and minimum transfer rate.

e) Overfill alarm calculations showing time available between alarm setting and overfill at max. loading rate for each tank.

f) Determination of maximum loading rate.

g) Fitting and test certificate for detonation flame arrester, if relevant.

h) Fitting and documentation regarding oxygen analyzer and alarm etc., if relevant.

i) Details of insulating flange, if relevant.

j) Instruction manual.

Section 2

Vapour Piping Systems

2.1 Material

2.1.1 Permanent piping

Piping material is to be as required for cargo tank venting system.

2.1.2 Flexible hoses

Material of hoses is to be resistant to vapours handled and hoses are to comply with the following:

- Maximum allowable working pressure is to be at least 0.34 bar.
- The hoses are to be capable of withstanding at least 0.14 bar vacuum without collapsing.
- Burst pressure is not to be less than five times the maximum allowable working pressure.
- The hoses are to be electrically continuous with a maximum resistance of 10,000 ohms.
- Hoses are to be abrasion resistant and non-kinking.
- Be provided with suitable hose handling equipment.

2.2 Vapour collection piping

2.2.1 General

Each vessel is to have vapour collection piping which is permanently installed, with a tanker vapour connection located as close as practical to the loading manifold. In lieu of permanent piping, chemical tankers are permitted to have a permanent vapour connection at each cargo tank for connection to a vapour hose which should be kept as short as practicable and in no case longer than 3 [m].

If a tanker simultaneously collects vapours from cargoes, which react in a hazardous manner with other cargoes these incompatible vapours are to be kept separate throughout the entire vapour collection system.

Means are to be provided to eliminate liquid condensate which may collect in the system, such as draining and collecting liquid from each low point in the line.

Vapour collection piping is to be electrically bonded to the hull and to be electrically continuous.

When inert gas distribution piping is used for vapour collection piping means to isolate the inert gas supply from the vapour collection system is to be provided. The inert gas main isolation valve required in Pt.5, Ch.2, Sec.11, Cl.11.6.12 may be used to satisfy this requirement.

The vapour collection system is not to disable the proper operation of the cargo tank venting system. However, a vapour collection piping may be common or partly common with the vent piping and/or the Inert Gas System and Inert Gas Piping System piping (Pt.5, Ch.2, Cl.11.7).

2.2.2 Vapour manifold

OCIMF's Recommendations for Oil Tanker Manifolds and Associated Equipment (latest revision) is also to be referred.

An isolation valve capable of manual operation is to be provided at each tanker vapour connection. The operating position of this valve is to be readily determined visually (open/closed indication).

The end of each vapour collection pipe or vapour collection hose is to be readily identifiable to prevent mis-connection.

In order to prevent the possible mis-connection of the vapour manifold to a shoreside terminal liquid loading line, each vapour connection flange is to conform to the applicable industry standard (OCIMF). This provision is applicable regardless of the size of the ship.

Number and position

Four vapour connections are to be provided, two on each side of the ship, with presentation flanges at the same height above the deck as the cargo manifold. One vapour connection is to be located forward of the manifold and one located aft of the manifold on each side of the ship.

Labelling

The first 1.0 [m] inboard of each manifold is to be painted on its exterior surfaces, excluding flange faces. The painted area is to be divided into three bands with the outboard and inboard bands being red and 100 [mm] wide and the centre band being yellow and 800 [mm] wide.

2.3 Capacity

2.3.1 Pressure drop calculations

The capacity of the vapour collection system is to be documented through pressure drop / flowrate curves. When calculating pressure drop the following is to be used:

a) Vapour growth rate, (VGR) i.e. increase of flowrate due to vapourization of the cargo:

$$\mathrm{VGR} = 1 + 0.25\frac{\mathrm{P_v}, 45}{86.2}$$

$P_{v,}$ 45 = saturated vapour pressure at 45°C in kPa abs.

b) Density of the cargo vapour and air/inert gas mixture (δ_{va},45):

δ_{va},45 = [SG_v V_v,45 + V_a,45] 0.0324 $P_{p/v}$

SG_v = specific gravity of cargo vapour.

V_v,45 = partial volume of vapour at $45°\mathrm{C} = \frac{\mathrm{P_v},45}{\mathrm{P_t},45}$

Where,

P_t,45 = total vapour air pressure at 45°C in kPa abs.

V_a,45 = partial volume of air at 45°C = 1 – V_v,45

$P_{p/v}$ = cargo tank P/V valve pressure setting in kPa abs.

c) Maximum cargo tank pressure is not to exceed 80% of opening pressure of the P/V valves.

Note:

- For oil tankers calculations using mixture density of 3.0 [kg/m^3] and vapour growth rate of 1.25 will cover all cargoes the ship may carry.

- For chemical tankers mixture density of 3.6 [kg/m^3] and vapour growth rate of 1.2 will cover all chemicals except those with a Reid's vapour pressure above atmospheric (IBC Code 15.14). For these cargoes additional calculations are needed using values applicable for the actual cargoes. (See Section 7).

Section 7 lists density and vapour growth values for a range of actual cargoes.

Section 3

Instrumentation

3.1 Cargo gauging

3.1.1 Cargo tank gauging equipment

Each cargo tank of a tanker that is connected to a vapour collection system is to be equipped with a cargo gauging device which:

- provides a closed gauging arrangement that does not require opening the tank to the atmosphere during cargo transfer;

- allows the operator to determine the liquid level in the tank for the full range of liquid levels in the tank;

- indicates the liquid level in the tank, at the location where cargo transfer is controlled.

- if portable, is installed on tank during the entire transfer operation.

3.2 Cargo tank level alarms

3.2.1 High level alarm

Each cargo tank of a tanker is to be equipped with a high level alarm system, which is to:

- be independent of the cargo gauging system. However, for vessels where the notation VCS2 is envisaged, a high level alarm system integral with the cargo gauging system will be accepted.

- come into operation when the normal tank loading procedures fail to stop the tank liquid level exceeding the normal full condition;

- give a visual and audible tank high level alarm to the ship's operator;

- have alarms fitted in the cargo control room, where provided, but in each case in such a position that they are immediately received by responsible members of the crew;

- give alarm in the event of loss of power to the alarm system or failure of the electrical circuitry to the tank level sensor;

- be able to be function tested from the outside of the tank for proper operation prior to each transfer or contain an electronic self-testing feature which monitors the condition of the alarm circuitry and sensor.

3.2.2 Overfill alarm

For vessels where the notation VCS2 is envisaged, each cargo tank of a tanker is to be equipped with an overfill alarm system (High-high level) which is to:

- be independent of the cargo gauging system and the high level alarm system specified in 3.2.1 above.

- come into operation after the high level alarm, but early enough to allow for action to prevent tank overflow.

- give a visual and audible tank overfill alarm to the ship's operator.

- have alarms fitted in the cargo control room, where provided and in the cargo deck area.

- give alarm in the event of loss of power to the alarm system or failure of the electrical circuitry to the tank level sensor;

- be able to be checked from the outside of tank for proper operation prior to each transfer or contain and electronic self-testing feature which monitors the condition of the alarm circuitry and sensor.

3.3 Vapour pressure alarms

3.3.1 General

Each vapour collection system is to be fitted with a pressure sensing device that senses the pressure in the main vapour collection line, which:

- has a pressure indicator located on the vessel where the cargo transfer is controlled e.g. cargo control room (CCR);

- has a high pressure and a low pressure alarm that:

    - is audible and visible on the vessel where cargo transfer is controlled e.g. CCR;

    - give alarms at a high pressure of not more than 90 percent of the lowest pressure relief valve setting in the cargo tank venting system;

    - give alarms at a low pressure of not less than 100 [mm] WG for an inerted tankship, or the lowest vacuum relief valve setting in the cargo tank venting system for a non-inerted tank.

Pressure sensors fitted in each cargo tank are acceptable as equivalent to pressure sensors fitted in each main vapour collection line.

Section 4

Vapour Balancing

4.1 General

4.1.1 Application

Requirements in this section apply to ship's engaged in the transportation of bulk liquid cargoes between a facility and another ship and vice versa. Compliance with these requirements is necessary for assignment of class notation VCS2.

4.2 Design and equipment

4.2.1 Where the cargo tanks on a ship discharging cargo and a ship receiving cargo are inerted, the discharging ship must:

- have a means to inert the vapour transfer hose prior to transferring cargo vapour;

- have an oxygen analyzer with a sensor or sampling connection fitted within 3 [m] of the ship vapour connection which:

  - activates an audible and visible alarm at a location on the discharging ship where cargo transfer is controlled when the oxygen content in the vapour collection system exceeds 8 percent by volume;

  - has an oxygen concentration indicator located on the discharging ship from where the cargo transfer is controlled;

  - has a connection for injecting a span gas of known concentration for calibration and testing of the oxygen analyzer.(The installation of the oxygen analyzer is to be specially considered).

4.2.2 Where the cargo tanks on a ship discharging cargo are not inerted the vapour collection line on the receiving ship is to be fitted with an approved detonation arrester located within 3 [m] of the ship vapour connection.

4.2.3 An electrical insulating flange or one length of non-conductive hose is to be provided between the ship vapour connection on the service ship and the vapour connection on the ship being lightered or topped-up.

Section 5

Operational Instructions

5.1 Instruction manual

5.1.1 Operational instructions

Each tanker utilizing a vapour emission control system is to be provided with written operational instructions covering the particular system installed on the tanker. The instructions are to encompass the purpose and principles of operation of the vapour emission control system and provide an understanding of the equipment involved and associated hazards. In addition the instructions are to provide an understanding of operating procedures, piping connection sequence, start-up procedures, normal operations and emergency procedures. Instructions are also to include an understanding of the shoreside terminal equipment and operating procedures. The instructions are to be in working language of the ship and additionally a copy in English language is to be available on board ship.

Instructions are to contain information on the tanker's vapour collection system including:

- a line diagram of the tanker's vapour collection piping indicating the locations and purpose of all control and safety devices;
- the maximum allowable transfer rate as limited by the venting capacity of the pressure or vacuum relief valves, or any other factor which would limit the transfer rate;
- the maximum pressure drop in the ship's vapour collection system for various transfer rates;
- the pressure relief settings of each pressure and vacuum relief valve;
- pre-transfer procedures;
- procedures are to be followed in the event of a fault during vapour collection operations.

The operational limitations and conditions given in Section 6 are to be reflected in the Operational Instructions.

Section 6

Operational Limitations and Conditions to be Reflected in the Instruction Manual

6.1 Procedures

6.1.1 Established industry guidelines are to be observed, as applicable, with regard to preparation for transfer and transfer of cargo and ballast into cargo tanks.

6.1.2 The rate of cargo transfer is not to exceed the maximum allowable transfer rate as determined by the lesser of the following:

- the venting capacity of the pressure relief valves in the cargo tank venting system divided by a factor of at least 1.25

- the vacuum relieving capacity of the vacuum relief valves in the cargo tank venting system

- the rate based on pressure drop calculations for a given pressure at the vapour connection facility, such that the pressure in any cargo tank connected to the vapour collection system does not exceed 80% of the opening set pressure of any pressure relief valve in the cargo tank venting system.

6.1.3 When the venting capacity is dimensioned for thermal breathing only, the capacity of the P/V breaker as required by SOLAS for IG systems is to be regarded as the basis for venting in the determination of the total permissible loading rate.

6.1.4 A cargo tank is not to be filled higher than the level at which the overfill alarm is set.

6.1.5 A cargo tank is not to be opened to the atmosphere for gauging or sampling while the tanker is connected to a vapour emission control system unless loading to the tank is stopped, the tank is isolated from any other tank which is in the process of being loaded and precautions are taken to reduce any pressure in the cargo tank vapour space and prevent an electrostatic spark from occurring.

6.1.6 If the tanker is equipped with an inert gas system the isolation valve required by Pt.5, Ch.2, Cl.11.6.12 is to remain closed during vapour transfer.

6.1.7 Unless equipped with an automatic self-test and circuit monitoring feature, each tank level alarm system required by 3.2 on a cargo tank being loaded, is to be tested at the tank for proper operation prior to the start of cargo transfer.

Section 7

List of Cargoes – Vapour Control

7.1 List of cargoes

7.1.1 This list covers a range of cargoes normally carried and gives vapour pressure and specific gravity, as well as density of vapour/air mixture and vapour growth rate at 45°C.

Chemical name	Vapour pressure 45°C kPa, abs.	Vapour specific gravity	Vap/air density 45°C [kg/m^3]	Vapour growth rate
Acetic acid	6,34	2,07	1,413	1,02
Acetic anhydride	2,76	3,50	1,414	1,01
Acetone	68,95	2,00	2,098	1,20
Acetone cyanohydrin	2,76	2,90	1,396	1,01
Acetonitrile	0,21	1,41	1,339	1,00
Acrylic acid	2,76	2,48	1,383	1,01
Acrylonitrile	34,47	1,80	1,642	1,10
Adiponitrile	0,07	3,73	1,340	1,00
Allyl alcohol	12,41	2,00	1,475	1,04
Allyl chloride	73,08	2,64	2,660	1,21
Aminoethylethanolamine	0,07	3,59	1,340	1,00
Amyl acetate (commercial, iso-, n-, sec-)	2,34	4,50	1,429	1,01
Amyl acetate (iso-)	2,34	4,50	1,429	1,01
Amyl acetate (n-)	2,34	4,50	1,429	1,01
Aniline	0,28	3,22	1,345	1,00
Benzene (50/50 mix air)	31,03	2,80	2,542	1,09
Benzene, Toluene, Xylene mixture (10% Benzene or more)	50,33	2,80	2,337	1,15
Benzyl chloride	0,62	4,36	1,361	1,00
Butyl acetate (n-)	5,52	4,00	1,521	1,02
Butyl acetate (iso-, n-)	4,14	4,00	1,475	1,01
Butyl acetate (sec-)	10,34	4,00	1,680	1,03
Butyl acrylate (iso-, n-)	4,14	4,42	1,494	1,01
Butyl alcohol (iso-)	6,21	2,60	1,448	1,02
Butyl alcohol (n-)	3,45	2,60	1,399	1,01
Butyl alcohol (sec-)	8,96	2,60	1,496	1,03
Butyl alcohol (tert-)	19,31	2,60	1,679	1,06
Butyl benzyl phthalate	0,07	10,80	1,346	1,00
Butyl ether (n-)	2,76	4,50	1,445	1,01
Butyl methacrylate	2,00	4,90	1,424	1,01
Butylamine (all isomers) (vap. Press. Varies between (3.2-15)	68,95	2,50	2,479	1,20
Butylene glycol	0,07	3,10	1,340	1,00
Butylene oxide (1,2-)	49,64	2,49	2,154	1,14
Butyraldehyde (iso-, n-)	55,16	2,48	2,238	1,16
Butyraldehyde (n-, crude)	55,16	2,48	2,238	1,16
Butyraldehydes (crude)	55,16	2,48	2,238	1,16
Butyric acid	0,48	3,04	1,349	1,00

Chemical name	Vapour pressure 45°C kPa, abs.	Vapour specific gravity	Vap/air density 45°C [kg/m^3]	Vapour growth rate
Caprolactam solutions	4,83	3,90	1,492	1,01
Carbon disulfide	3,45	2,67	1,400	1,11
Carbon tetrachloride	37,23	5,49	3,181	1,02
Chloro-benzene	5,52	3,88	1,513	1,18
Chloro-form	62,05	4,25	3,562	1,00
Chloro-sulfonic acid	0,55	4,00	1,356	1,00
Creosote (all isometers)	0,07	3,72	1,340	1,00
Creosote (cole tar)	0,07	3,72	1,340	1,00
Creosote (wood)	0,07	3,72	1,340	1,00
Cresols	0,41	3,72	1,351	1,04
Crotonaldehyde	13,79	2,41	1,552	1,01
Cumene	4,14	4,20	1,484	1,09
Cyclo-hexane	31,03	2,90	1,988	1,00
Cyclo-hexanol	1,38	3,50	1,376	1,00
Cyclo-hexanone	1,38	3,40	1,375	1,01
Cyclo-hexylamine	4,27	3,42	1,452	1,01
Cymene (para)	3,17	4,62	1,465	1,01
Decaldehyde (iso-)	0,41	5,38	1,358	1,00
Decyclopentadiene	1,72	4,55	1,406	1,01
Decyl alcohol (all isomers)	0,07	5,30	1,341	1,00
Decyl alcohol (iso-)	0,07	5,30	1,341	1,00
Decyl alcohol (n-)	0,07	5,30	1,341	1,00
Decyl acrylate (iso-, n-)	0,07	7,30	1,343	1,00
Diacetone alcohol	0,69	4,00	1,361	1,00
Dibutylamine	1,24	4,46	1,385	1,00
Dichlorobenzene (all isomers)	0,69	5,07	1,369	1,00
Dichloroethane (1,1-)	68,26	3,41	3,152	1,20
Dichloroethyl ether (2, 2-)	0,28	4,90	1,350	1,00
Dichloromethane	131,00	3,00	4,227	1,38
Dichlorophenol (2, 4-)	0,07	5,60	1,342	1,00
Dichloropropane (1, 2-)	17,24	3,89	1,887	1,05
Dichloropropene (1, 3-)	37,92	3,84	2,526	1,11
Diethanolamine	0,07	3,65	1,340	1,00
Diethylamine	6,89	2,50	1,452	1,02
Diethyl-benzene	0,55	4,62	1,360	1,00
Diethylene glycol	0,07	3,66	1,340	1,00
Diethylene glycol butyl ether	0,07	5,50	1,342	1,00
Diethylene glycol ethyl ether	0,07	4,62	1,341	1,00
Diethylene glycol methyl ether	0,14	4,14	1,343	1,00
Diethylenetriamine	0,28	3,48	1,346	1,00
Diethylethanolamine	1,03	4,03	1,373	1,00
Diisobutyl ketone	3,31	4,90	1,480	1,01
Diisobutylamine	3,17	4,46	1,459	1,01
Diisobutylcarbinol	0,69	4,98	1,368	1,00
Diisobutylene	15,17	3,97	1,835	1,04
Diisopropanolamine	0,07	4,59	1,341	1,00
Diisopropylamine	25,51	3,50	2,041	1,07
Diethylamine solution (45% or less)	70,33	1,55	1,765	1,20
Dimethylformamide	2,07	2,51	1,373	1,01
Dioctyl phthalate	0,07	13,45	1,348	1,00

Chemical name	Vapour pressure 45°C kPa, abs.	Vapour specific gravity	Vap/air density 45°C [kg/m^3]	Vapour growth rate
Dioxane (1, 4-)	12,41	3,00	1,612	1,04
Diphenyl, Diphenyl ether mixture	0,07	5,87	1,342	1,00
Diphenyl methane diisocyanate	0,07	8,50	1,344	1,00
Dipropylene glycol	0,48	4,63	1,357	1,00
Dipropylene glycol dibenzoate	0,07	8,50	1,344	1,00
Dodecene	0,14	5,81	1,345	1,00
Dodecyl benzene	32,41	8,40	3,982	1,09
Epichlorohydrin	6,89	3,19	1,505	1,02
Ethanolamine	0,21	2,10	1,341	1,00
Ethoxy triglycol (crude)	0,07	6,14	1,342	1,00
Ethyl acetate	31,03	3,04	2,036	1,09
Ethyl acrylate	13,79	3,50	1,718	1,04
Ethyl alcohol	24,13	1,60	1,498	1,07
Ethyl butanol	0,97	3,40	1,364	1,00
Ethyl ether	158,58	2,55	4,049	1,46
Ethyl hexanol (2-)	0,14	4,50	1,343	1,00
Ethyl methacrylate	6,89	3,94	1,562	1,02
Ethyl-3-propylacrolein (2-)	0,83	4,35	1,369	1,00
Ethylamine	281,31	1,55	3,044	1,82
Ethylamine solution (72% or less)	106,87	1,56	1,998	1,31
Ethylbenzene	4,14	3,56	1,455	1,01
Ethylbutylamine (n-)	8,27	3,50	1,566	1,02
Ethylene chlorohydrine	3,03	2,78	1,398	1,01
Ethylene cyanohydrin	0,07	2,45	1,339	1,00
Ethylene dibromide	0,48	6,50	1,367	1,00
Ethylene dichloride	27,58	3,42	2,074	1,08
Ethylene glycol	0,07	2,21	1,339	1,00
Ethylene glycol butyl ether	22,08	4,07	2,085	1,06
Ethylene glycol ethyl ether	1,17	3,10	1,365	1,00
Ethylene glycol methyl ether	4,14	2,62	1,412	1,01
Ethylene diamine	6,21	2,10	1,413	1,02
Ethyl hexyl acrylate (2-)	0,14	6,35	1,346	1,00
Ethylidene norbomene	2,28	4,10	1,416	1,01
Formaldehyde solution (37% to 50%)	1,03	1,03	1,338	1,00
Formic acid	14,48	1,60	1,434	1,04
Furfural	1,03	3,31	1,364	1,00
Furfuryl alcohol	0,69	3,37	1,356	1,00
Gasoline blending stocks: Alkylates (50/50 mix air)	86,18	3,40	2,944	1,25
Gasoline blending stocks: Reformates (50/50 mix air)	86,18	3,40	2,944	1,25
Gasolines: Automotive (< 4,23 grams lead/gallon) (50/50 mix air)	86,18	3,40	2,944	1,25
Gasolines: Aviation (< 4,86 grams lead/gallon) (50/50 mix air)	86,18	3,40	2,944	1,25

Chemical name	Vapour pressure 45°C kPa, abs.	Vapour specific gravity	Vap/air density 45°C [kg/m^3]	Vapour growth rate
Gasolines: Casing head (natural) (50/50 mix air)	86,18	3,40	2,944	1,25
Gasolines: Polymer (50/50 mix air)	86,18	3,40	2,944	1,25
Gasolines: Straight run (50/50 mix air)	86,18	3,40	2,944	1,25
Glycerine	0,07	3,17	1,340	1,00
Heptane (all isomers)	17,24	3,45	1,804	1,05
Heptane (n-)	17,24	3,45	1,804	1,05
Hexamethylenediamine solution	0,07	1,00	1,338	1,00
Hexane (all isomers) (average vap. Pressure, real: 7-9)	55,16	3,00	2,555	1,16
Hexane (average vap. Pressure, real: 7-9)	55,16	3,00	2,555	1,16
Hexanol (1-)	6,89	3,52	1,530	1,02
Hydrochloric acid	72,39	1,26	1,546	1,21
iso-Butyraldehyde	55,16	2,48	2,238	1,16
iso-Propylamine	159,27	2,04	3,165	1,46
isophorone	0,07	4,75	1,341	1,00
Isoprene	158,58	2,35	3,699	1,46
Kerosene	1,03	4,50	1,378	1,00
Light virgin Naphta	96,53	0,66	0,976	1,28
Mesityl oxide	4,62	3,50	1,465	1,01
Methacrylic acid	0,69	2,50	1,350	1,00
Methacrylonitrile	74,46	1,17	1,478	1,22
Methyl acetate	42,06	2,60	2,080	1,12
Methyl acrylate	28,27	3,00	1,962	1,08
Methyl alcohol	48,26	1,11	1,397	1,14
Methyl ethyl ketone	31,03	2,50	1,851	1,09
Methyl isobutyl ketone	8,27	3,45	1,562	1,02
Methyl methacrylate	13,93	3,45	1,714	1,04
Methyl-5-ethyl-pyridine (2-)	1,10	4,18	1,377	1,00
Methyl-6-ethyl-aniline (2-)	0,07	4,67	1,341	1,00
Methylamine solution, 40%	89,63	1,07	1,407	1,26
Methylamyl acetate	2,34	5,00	1,441	1,01
Methylamyl alcohol	2,76	3,50	1,414	1,01
Methylpyridine (2-)	3,45	3,20	1,422	1,01
Methyl styrene (alpha-)	2,76	4,08	1,432	1,01
Mineral spirits (average vapour s.g.)	1,38	4,15	1,386	1,00
Morpholine	5,52	3,00	1,460	1,02
Naphtalene (molten)	0,07	4,42	1,341	1,00
Nitric acid (70% or less)	24,82	2,17	1,658	1,07
Nigrobenzene	0,14	4,24	1,343	1,00
Nitropropane (1- or 2-)	7,24	3,06	1,503	1,02
Nitrotoluene (o-, p-)	0,14	4,72	1,344	1,00
Nonane	2,76	4,41	1,442	1,01
Nonene	2,41	4,30	1,426	1,01
Nonyl phenol	0,07	7,59	1,343	1,00
Octyl alcohol (iso-)	0,21	4,50	1,346	1,00
Octyl nitrates (all isomers)	2,14	6,00	1,456	1,01

Chemical name	Vapour pressure 45°C kPa, abs.	Vapour specific gravity	Vap/air density 45°C [kg/m^3]	Vapour growth rate
Oil, edible: castor	1,03	10,00	1,441	1,00
Oil, Misc.: Crude	1,03	1,00	1,338	1,00
Oleum	0,07	2,76	1,339	1,00
Paraldehyde	57,23	4,55	3,578	1,17
Pentadiene (1, 3-)	117,62	2,36	3,102	1,34
Pentane (all isomers)	144,79	2,48	3,701	1,42
Pentane (iso-)	186,16	2,48	4,376	1,54
Perchloroethylene	8,48	5,83	1,790	1,02
Phenol, or solutions with 5% or more Phenol	4,14	3,24	1,440	1,01
Phosphoric acid	0,07	3,38	1,340	1,00
Phthalic anhydride (molten)	0,07	5,10	1,341	1,00
Propanolamine (iso-, n-)	0,55	2,59	1,348	1,00
Propionaldehyde	96,53	2,00	2,402	1,28
Propionic acid	2,07	2,56	1,374	1,01
Propionic anhydride	0,07	4,49	1,341	1,00
Propionitrile	16,55	1,40	1,411	1,05
Propyl acetate (iso-)	21,37	3,52	1,932	1,06
Propyl acetate (n-)	13,10	3,52	1,702	1,04
Propyl alcohol (iso-)	20,68	2,07	1,582	1,06
Propyl alcohol (n-)	8,27	2,07	1,436	1,02
Propyl alcohol (n-)	92,39	2,04	2,398	1,27
Propylene oxide	151,68	2,00	3,011	1,44
Pyridine	8,96	2,72	1,508	1,03
Sodium hydrosulfide solution (45% or less)	10,41	1,17	1,358	1,03
Sorbitol solution	0,07	3,20	1,340	1,00
Styrene	2,76	3,60	1,417	1,01
Styrene (curde)	2,76	3,60	1,417	1,01
Sulfufic acid	0,07	3,40	1,340	1,00
Tetrachloroethane (1, 1, 2, 2-)	6,89	5,80	1,703	1,02
Tetraethylene glycol	0,07	6,70	1,342	1,00
Tetraethylene pentamine	0,07	6,80	1,343	1,00
Tetrahydrofuran	58,61	1,35	1,564	1,17
Tetrahydronaphtalene	0,28	4,55	1,349	1,00
Toluene	10,34	3,14	1,582	1,03
Toluene diisocyanate	0,07	6,00	1,342	1,00
Trichlorobenzene (1, 2, 4-)	0,07	6,26	1,342	1,00
Trichloroethane (1, 1, 1-)	33,78	4,60	2,679	1,10
Trichloroethylene	24,13	4,54	2,280	1,07
Trichloropropane (1, 2, 3-)	1,03	5,60	1,391	1,00
Tricresyl phosphate (1% or more of ortho isomer)	0,07	12,70	1,347	1,00
Tricresyl phosphate (less than 1% of ortho isomer)	0,07	12,70	1,347	1,00
Tridecanol	0,07	6,70	1,343	1,00
Triethanolamine	0,07	5,14	1,341	1,00
Triethylamine	17,24	3,49	1,811	1,05
Triethyl benzene	0,34	5,60	1,356	1,00
Triethylene glycol	0,07	5,17	1,341	1,00
Triethylene glycol methyl ether	0,07	5,66	1,342	1,00
Triethylenetetramine	0,07	5,04	1,341	1,00

Chemical name	Vapour pressure 45°C kPa, abs.	Vapour specific gravity	Vap/air density 45°C [kg/m^3]	Vapour growth rate
Tripropylene glycol	0,07	6,63	1,342	1,00
Turpentine	0,28	4,84	1,350	1,00
Valeraldehyde (iso-, n-)	12,41	2,96	1,606	1,04
Valeraldehyde (n-)	12,41	2,96	1,606	1,04
Vinyl acetate	39,99	2,97	2,207	1,12
Vinyl ethyl ether	143,41	2,49	3,694	1,42
Vinylidene chloride	165,47	3,34	5,608	1,48
Vinyltoluene	0,83	4,08	1,366	1,00
Xylene (m-)	3,52	3,66	1,441	1,01
Xylene (p-)	3,52	3,66	1,441	1,01
Xylene (o-)	2,76	3,66	1,419	1,01

End of Chapter

Chapter 30

Environmental Protection

Contents

Section

Section 1

General Requirements

1.1 Application

1.1.1 A ship or a marine structure meeting the requirements for Environmental protection of this chapter will be assigned notations indicated in 1.1.2 to 1.1.4 below and a suitable entry will be made in the Register Book. Compliance with this chapter and the assignment of notations is optional.

1.1.2 In order to be eligible for the class notation "EP", a ship is to meet the requirements covered in Section 2, Section 3 and Section 4.

1.1.3 Section 2 gives the requirements to be complied with for control and prevention of polluting substances into the sea. A ship meeting the requirements of this section will be eligible for notation "CLEAN-SEA".

1.1.4 Section 3 gives the requirements to be complied with for control and prevention of emission of polluting substances in the air. A ship meeting the requirements of this section will be eligible for notation "CLEAN- AIR".

1.1.5 It is a prerequisite for assignment of the class notation EP that the applicable requirements of the following Annexes to the International Convention for the Prevention of Pollution from ships, MARPOL 73/78, as amended are fully complied with.

i) Annex I – Regulations for the Prevention of Pollution by Oil

ii) Annex II – Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk

iii) Annex III – Regulations for the Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form

iv) Annex IV – Regulations for the Prevention of Pollution by Sewage from Ships

v) Annex V – Regulations for the Prevention of Pollution by Garbage from Ships

vi) Annex VI – Regulations for the Prevention of Air Pollution from ships.

In addition to above, the following International Standards, guidelines and recommendations are also to be complied with, as applicable:

i) Diesel Engine Exhaust NOx Content – NOx Technical Code, (2008), Resolution MEPC 177(58).

ii) Refrigerants and fire-fighting gases – Montreal Protocol on Substances that Deplete the Ozone Layer

iii) Shipboard Incinerators – IMO Resolution MEPC 76(40) Standard Specification for Shipboard Incinerators

iv) Cargo Vapour Emission Control – IMO standard for Vapour Emission Control Systems, MSC/Circ.585 or USCG Title 46 CFR Part 39 Vapour Control System (See part 5, Ch. 29

of the Rules for Construction and Classification of Steel ships)

v) Ballast Water – Resolution A.868 (20). Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Organisms and Pathogens

vi) International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001.

Where the flag administration has additional requirements to the above related environmental protection, those requirements are to be complied with and applicable certificates of compliance are to be obtained by the owners, for assignment of the EP notation.

1.1.6 Compliance with the rules are to be verified through inspection, measurements and sampling of defined environmental parameters in accordance with the requirements of the rules in this chapter and with identified standards or guidelines.

1.1.7 Environmental management systems, e.g. ISO 14000, are not part of the rules. Fulfillment of the requirements in the rules may, however, facilitate goals and improvement tasks defined through ISO 14000 implementation.

1.1.8 Special ship types and ships with unconventional propulsion machinery systems see Table 1; will be subject to special consideration covering specific items not covered by the standard rules. Tankers for oil smaller than 150 tons gross tonnage and other ships smaller than 400 tons gross tonnage will also be subject to special consideration.

1.1.9 Any matter detrimental to the environmental performance of the ship in turn affecting the assignment of the EP class notation should be notified to IRS.

Table 1 : Ship types and propulsion machinery systems that will be specially considered
Ship types: Liquefied gas carriers Floating storage, production and offloading systems
Propulsion machinery systems: Gas turbines

1.2 Definitions : main parameters

1.2.1 Emissions to air or emissions

All emissions to air which are caused by or needed for the operation of the ship, energy consumers, cargo, passengers and crew on board a vessel and any toxic emissions caused by operation, protection and conservation of vessel or cargo.

1.2.2 Discharges to sea or discharges

All discharges to sea which are caused by or needed for operation of the ship, energy consumers, cargo, passengers and crew on board a vessel and any toxic discharges caused by protection and conservation of vessel or cargo.

1.2.3 Deliveries to shore

Delivery of potential pollutants to shore for controlled disposal, recycling etc.

1.2.4 Accidental emissions or discharges

All emissions to air or discharges to sea, caused by unforeseen or unplanned events, of substances needed for energy consumers, cargo, passengers and crew on board a vessel and any toxic emissions caused by protection and conservation of vessel or cargo.

1.3 Definitions and characteristics, systems and components

1.3.1 Ballast water system

Ballast water systems comprise:

- Tanks for ballast water
- Associated piping and pumping systems.

Environmental effects from ballast water covered by the rules in this chapter may include:

- Transport and discharge of harmful aquatic organisms and pathogens.

Combined cargo/ballast tanks are not considered by the rules in this chapter.

1.3.2 Bilge water

Bilge water is oily water removed from the machinery space bilges. Bilge water removed from cargo holds of bulk carriers and general cargo vessels is not affected by the rules in this chapter.

1.3.3 Cargo handling systems

Cargo handling systems covered by the rules in this chapter comprise:

- Cargo tank vents for tankers with cargoes where evaporation may occur during loading, transport and discharge. (e.g. Tanker for Oil, Tanker for Chemicals, Tanker for Liquefied Gas)

- Pumping and piping systems for tankers carrying cargoes that may cause global or local pollution.

1.3.4 Cargo residues

Cargo residues cover remains of cargo (oil or chemical contaminated water from cargo tank area, slop tanks and cargo pump room). Cargo residues may be present in discharged water used for cleaning cargo tanks and discharged ballast water from tankers without 100% segregated ballast tanks.

1.3.5 Casualty

Casualties covered by the rules in this chapter are defined as serious unplanned incident(s), e.g. grounding, collision or other incident damaging the hull's structural integrity, fire, sinking etc. The consequence of a situation of total loss will be:

- Cargo, or cargo containment system, is damaged and cargo spilt into the sea
- The integrity of the ship is damaged causing oil spills, etc.

1.3.6 Combustion machinery

Combustion machinery comprises:

- Internal combustion engines, both marine diesel engines and gas turbines
- Boilers.

The rules in this chapter cover the emission of oxides of nitrogen (NO_x) and sulphur (SO_x) from combustion machinery exhaust gases to the atmosphere

1.3.7 Fire-fighting system

The rules in this chapter cover the active fire-fighting media used in fixed fire-righting systems.

1.3.8 Garbage

Garbage includes all kinds of victual, domestic and operational waste excluding fresh fish and parts thereof, generated during normal operation of the ship and liable to be disposed of continuously or periodically except those substances excluded specifically. Garbage generated by passengers on passenger vessels is included in the rules in this chapter.

Systems for garbage treatment include the following:

- Garbage sorting systems, typically: glass, paper, metals etc.
- Compacting systems
- Storage systems
- Incinerators.

Sewage and waste oils are defined separately and not as garbage.

1.3.9 Painting and antifouling systems

Antifouling paint of the underwater area gives a continuous discharge of active ingredients to the sea. This effect is covered by the rules in this chapter.

In addition, painting and antifouling systems emit volatile organic compounds (VOC) during application. This effect is not considered by the rules in this chapter.

1.3.10 Port

The ship is considered in port from ordering "stand by" prior to entering port to ordering "full ahead" when leaving the port. The time will be confirmed by entries in the ship's logbook.

1.3.11 Refrigeration systems

The rules in this chapter cover refrigerant media used in refrigeration plants on conventional reefer ships, fishing vessels, liquefied gas carriers with re-liquefaction plants and other ships with centralized cargo refrigeration systems. They are also applicable for centralized air conditioning and refrigeration systems onboard. Domestic type stand-alone air conditioning units and refrigerators are not covered.

Refrigerants may escape to the atmosphere through refrigeration system leakage, service work and dismantling at the end of the system's working life.

1.3.12 Sewage

Sewage is defined to include:

- Drainage and other wastes from all toilets, urinals and WC scuppers. For passenger ships this applies both for crew and passenger areas
- Drainage from medical premises (dispensary, sick bay etc.) via wash basins, wash tubs and scuppers located in such rooms
- Drainage from spaces containing living animals, or
- Other waste waters when mixed with any of the drainage systems defined above.

Systems for sewage handling have varying complexity including:

- Holding tanks
- Sewage treatment plants, e.g.:
  - Disinfecting
  - System for separating solids from liquids
  - Comminuters/grinders
  - Discharge systems, ashore, or to sea.

1.3.13 Waste oil

Shipboard waste oils comprise the following:

- Used lubrication and hydraulic oils
- Oil leaked from lubrication and hydraulic oil systems
- Leakage from fuel oil systems
- Sludge from fuel and lubrication oil treatment systems (separators, filters, etc.).

Waste oils may be dealt with onboard, or pumped ashore. Cargo residues in slop tanks, etc. are considered separate from operational waste oils.

1.4 Abbreviations

BCH Code	Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (Bulk Chemical Code)
CFC	Common name for refrigerants, e.g. : CFC-11 (Trichlorofluoromethane), CFC-12 (Dichlorofluoromethane) etc.
CFR	Code of Federal Regulations
GWP	Global Warming Potential (CO_2 = 1, time horizon 100 years)
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
IACS	International Association of Classification Societies
IAPP Certificate	International Air Pollution Prevention Certificate
IBC Code	The International Code for the Construction and Equipment of ships Carrying Dangerous Chemicals in Bulk
IOPP Certificate	International Oil Pollution Prevention Certificate
ISM Code	"International Safety Management (ISM) Code"' means the International Management Code for the Safe Operation of Ships and for Pollution Prevention as adopted by the Organization (IMO) by resolution A.741(18), as may be amended by the Organization. (ISM Code 1.1)
ISO	International Organization for Standardisation
IMO	International Maritime Organization
MARPOL or MARPOL 73/78	The International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 thereto
MSC	Maritime Safety Committee (IMO)
MEPC	Maritime Environmental Protection Committee (IMO)
NO_x	Oxides of nitrogen
ODP	Ozone depleting potential (Compared to CFC 11)
SCR	Selective Catalytic Reduction
SO_x	Oxides of sulphur
TBT	Tributyltin (active ingredient in antifouling paint)
USCG	US Coast Guard
VOC	Volatile organic compound

1.5 International recommendations, standards and references

1.5.1 International recommendations, standards and references have been used as foundation for the rules, although even if the rule requirements may be more stringent. When setting the emission and discharge limits and determining the measuring procedure, due consideration has been given to technical and practical limitations inherent in the design and construction of different types of ships.

1.5.2 International recommendations, standards and references with provisions used by IRS when developing the rules are reflected in the references specified in 1.1.5. Unless a particular edition is explicitly referred to, the latest edition of each standard applies.

1.6 Information and Documentation

1.6.1 All plans, certificates, operational procedures and other documentation of compliance as detailed in section 2, 3 and 4 are to be available to IRS prior to assigning the class notation “CLEAN-SEA” OR “CLEAN- AIR” OR “ EP”

1.6.2 Discharge limiting and monitoring equipment are to be certified as type approved.

1.7 Environmental management Plan

1.7.1 An Environmental Management Plan, specific to the ship is to be developed and submitted to IRS for information describing at least the procedures given in sections 2, 3 and 4 respectively.

Section 2

Clean Sea Notation

2.1 Application

2.1.1 This section gives the requirements applicable for assignment of the Notation “CLEAN-SEA”

2.2 Information and Documentation

2.2.1 Table 2.1 lists the documents, to be submitted for approval and/or information in connection with prevention of polluting substances into sea:

- i) by oil
- ii) by noxious liquid substances
- iii) by harmful substances carried by sea in packaged form
- iv) by sewage
- v) by garbage
- vi) by other sources

The documents listed in Table 2.1 do not take account of drawings necessary for the issuance of the “International Pollution Prevention certificate for the Carriage of Noxious Liquid Substances in Bulk” or of the “International Certificate of Fitness for the Carriage of dangerous Chemicals in Bulk” as applicable.

Guidance note:

It should be noted that some of the required documentation is additional to and different from documentation normally considered “Class documentation” as delivered from the new building yard. This is in particular the case for operational procedures specified in section 2, 3 or 4 as applicable that may require input from the Owner.

2.3 Design and procedural requirements

2.3.1 Prevention of sea pollution by oils

2.3.1.1 General

Provided the ship has been granted a valid IOPP certificate issued by an Administration or by a recognized organization on behalf of an Administration, in accordance with MARPOL 73/78 Annex I, as applicable, the additional specific requirements as per 2.3.1.2, 2.3.1.3 & 2.3.1.4 apply.

Table 2.1 : Documents to be submitted in connection with prevention of polluting substances into sea

No.	A/I	Document
1	I	Copy of the IOPP Certificate
2	A	Drawings with indication of tanks' volume and distance from the base line and shell plates as per 2.3.1.2 **(1)**
3	A	Schemes of the fuel oil, lubricating oil and relevant residue systems details containing the necessary information to verify the requirements as per 2.3.2 **(1)**
4	I	Oil Systems Record Book
		(1) if these details are shown in the drawings which are used for the classification of the ship, such drawings and schemes may also be used to verify the requirements of these rules. Note : A = to be submitted for approval in four copies; I = to be submitted for information in duplicate.
5	I	Copy of the "International Pollution Prevention Certificate for the Carriage of Noxious Liquid Substances in Bulk" or copy of the "International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk" as applicable.
		(1) I = to be submitted for information in duplicate.
6	I	General arrangement plan with indication of the zone intended for the stowage of the harmful packaged substances in relation to the other zones of the ship
7	I	Plans of systems and equipment to discharge the harmful substances in case of emergency and to dispose of and water wash possible leaks
		(1) I = to be submitted for information in duplicate.
8	I	General arrangement plan with indication of the sewage treatment plant enclosing details on treatment procedures (2)
9	I	Copy of the ISPP Certificate and type approval certificate for the sewage treatment plant according to MEPC.159(55).
10	A	Calculation of volume of holding tank(s) for treated sewage
11	I	General information on control and monitoring systems (2)
12	I	Sewage record book
		Note A = to be submitted for approval in four copies; I = to be submitted for information in duplicate. (2) Not required if the sewage treatment plant is an approved type.
13	I	General information on garbage treatment equipment (2) (3)
14	A	Garbage management plan including garbage record book as specified by MARPOL 73/78 Appendix to Annex V
15	I	General description of control and monitoring systems of garbage treatment equipment (2)
		Note: A = to be submitted for approval in four copies; I = to be submitted for information in duplicate. **(2)** Not required if the garbage treatment equipment is of an approved type. **(3)** For incinerators see Sec.3.
16	A	Ballast water management plan, including a ballast water record book, developed in accordance with IMO Res.A.868(20)
17	I	Copy of the AFS Certificate and details of TBT free antifouling paint
18	A	Calculation of volume of grey water holding tank(s) (passenger ships only)
19	I	Grey water record book (passenger ships only)
		Note: A = to be submitted for approval in four copies; I = to be submitted for information in duplicate.
20	I	Ship Environmental Management Plan giving details as per 2.3.1.4, 2.3.3.6, 2.3.4.4, 2.3.5.4, 2.3.6.4 and 2.4.
		Note I = to be submitted in duplicate.

2.3.1.2 Tank arrangement

a) For the purpose of these rules, tanks for fuel oil, sludge tanks and tanks for lubricating oil, whether or not for waste, of capacity exceeding 30 [m^3] are to be considered. Tanks with capacity not exceeding 30 [m^3] may be excluded provided the aggregate capacity of such excluded tanks is not greater than 600 [m^3]. Overflow tanks are to be included unless they are provided with an alarm for detection of liquid and operational procedures are foreseen for keeping such tanks empty. Double bottoms for lubricating oil located under the main engine are not considered in these Rules.

b) Such tanks are to be located above the moulded line of the bottom shell plating nowhere less than the distance 'h' specified below:

h = B/20 [m] or 2.0 [m] whichever is lesser.
The minimum value of h = 0.76 [m].
In the turn of the bilge area and at locations without a clearly defined turn of bilge, the tank boundary line are to run parallel to the line of the midship flat bottom as shown in Fig.2.3.1.1.

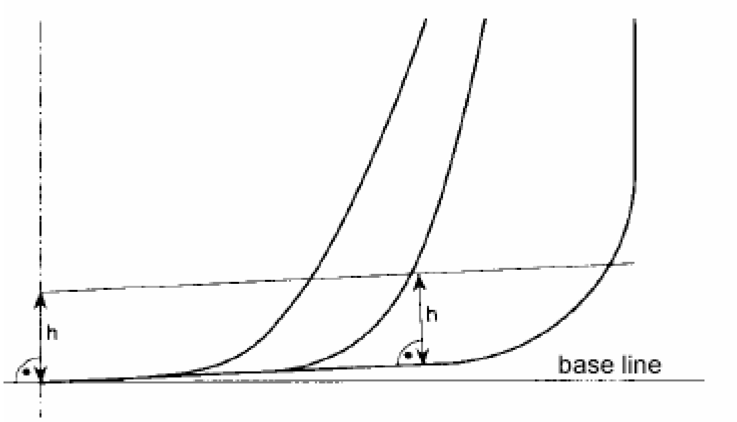


Fig.2.3.1.1 : Minimum distance of tank boundaries above bottom shell

c) For ships having an aggregate oil tank capacity of less than 5000 [m^3], such tanks are to be located inboard of the moulded line of the side shell plating, nowhere less than the distance "w" measured at right angles to the side shell as specified below: (See Fig.2.3.1.2).

w = 0.4 + 2.4 C/20000 [m];

The minimum value of w = 1.0 [m], however for individual tanks with oil capacity of less than 500 [m^3] the minimum value is 0.76 [m].

"C" is the total volume of the oil tanks [m^3] at 98% tank filling.

d) For ships having an aggregate oil tank capacity of 5000 [m^3] and over, such tanks are to be located inboard of the moulded line of the side shell plating, nowhere less than the distance "w" measured at right angles to the side shell as specified below: (See Fig.2.3.1.2)

w = 0.5 + C/20000 [m] or 2.0 [m], whichever is the lesser.
The minimum value of w = 1.0 [m].

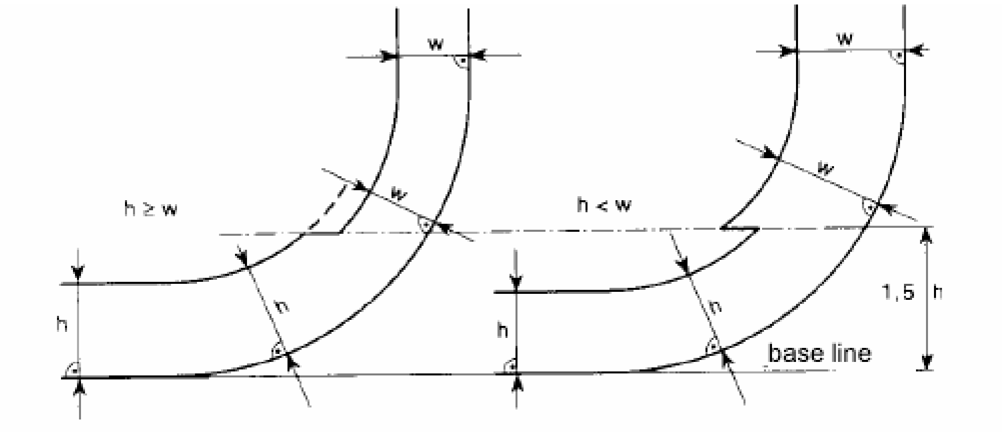


Fig. 2.3.1.2 : Minimum distance of tank boundaries from side shell

e) Lines of oil piping located at a distance from the ship's bottom of less than "h" as defined in b) or from the ship's side less than "w" as defined in c) and d) above, are to be fitted with valves or similar closing devices within or immediately adjacent to the oil tank.

These valves are to be capable of being brought into operation from a readily accessible enclosed space the location of which is accessible from the navigation bridge or propulsion machinery control position without traversing exposed decks. The valves are to close in case of remote control system failure (fail in a closed position) and are to be kept closed at sea at any time when the tank contains oil except that they may be opened during oil transfer operations.

f) Small suction wells in oil tanks may extend below the boundary line defined by the distance "h" provided that the distance between the well bottom and the bottom shell plating is not less than 0.5h.

g) Tanks of any volume intended to contain fuel or lubricating oil are not to be used also for ballast water.

h) All tanks and cofferdams, if any, around the tanks are to be so arranged as to be adequately inspected; such cofferdams are to be effectively protected against corrosion by means of proper protective coatings of a light colour in order to be easily examined.

2.3.1.3 Systems

i) Fuel oil and lubricating oil system

a) All fuel oil and lubricating oil tanks of capacity greater than 10 [m^3] are to be fitted with an overflow system and a high level alarm.

Acceptable alternatives are:

- An overflow system and a flow alarm in the overflow main
- No overflow system and two high level alarms (for instance at 90% and 95% of filling).

b) The alarms signals are to be given in a suitable station from which bunkering or transfer operations are controlled.

c) On the weather and/or superstructure decks each fuel or lubricating oil tank vent, overflows and fill pipe connection is to be fitted with a fixed container or enclosed deck area with a capacity of:

- 80 litres if the gross tonnage of the ship is between 300 and 1600
- 160 litres if the gross tonnage of the ship is greater than 1600.

ii) Oily bilge water system for machinery spaces

a) The oil filtering equipment, complying with MARPOL Annex I, is to be provided with an oil content meter and with a 15 ppm alarm combined with automatic stopping device.

b) The effluent from the 15 ppm filtering equipment is to be capable of being recirculated to a bilge holding tank. Such tank is to be so arranged as to allow periodical removal of sediments.

c) A holding tank is to be fitted for the pre-separation of bilge water before transferring it to the separating or filtering equipment.

d) The volume V of such a tank, in [m^3] is to be at least:

$V = 1 + 5.5P \mathbf{.}\ 10^{-4}$

Where P is the power of the propulsion engine plant in kW. In any case volume V need not be greater than 15 [m^3] .

In specific cases for instance with regard to the service, range and installed power, will be specially considered.

e) For ships operating with fuel oil having a mass density at 15°C greater than 0.94 [kg/cm^3] and viscosity at 50°C greater than 110 centistokes, the possibility of heating such a tank is to be provided.

iii) Sludge tank

a) Ships operating with heavy fuel oil are to be provided with tanks for sludge from the fuel oil purifiers without internal structures and with a suitable heating system.

b) The sludge tank is to be so arranged as to allow periodical removal of sediments. Sludge is either to be disposed of onboard through the incinerator or discharged ashore and is to be recorded in the oil record book.

c) Use of boilers for sludge disposal onboard is not allowed unless a treatment system or special device is installed to improve emissions generated by sludge incineration, subject to IRS's approval.

2.3.1.4 Procedures

a) The lub.oil consumption of all systems having an oil to sea interface, such as main and auxiliary engines cooled by sea water, controlled pitch propellers, sterntubes, bow and stern thrusters, stabilizers, PODs etc., is to be recorded at least once a week in an "Oil Systems, record book" aimed at detecting, through unusually high consumption, oil leakage through sealing.

The log-book is to contain the list of all systems concerned, the consumption of each system recorded at least every week and corrective actions when carried out.

b) The Ship Environmental Management Plan referred to in 2.4 is to include procedures covering the following:

- Oily waste management including discharge criteria;
- Preparation, filling in and maintenance of the oil record book and of the "Systems oil consumption log-book";
- Periodical calibration, at least every twelve months, of the oil content meter referred to in 2.3.1.3; documentation is to be kept on board for examination during periodical surveys;
- Periodical cleaning of the bilge holding tank and of the sludge tank;
- Spillage during bunkering;
- Periodical checks of the overflow systems/alarms.

2.3.2 Prevention of sea pollution by noxious liquid substances carried in bulk as cargo

2.3.2.1 Provided the ship has been granted a valid "NLS" or a valid "ICOF CHE" certificate, as applicable, issued by an Administration or by a recognized organisation on behalf of an Administration, in accordance with MARPOL 73/78 Annex II, as applicable, there are no additional specific requirements to be complied with on this matter for the purpose of the issuance of the CLEAN-SEA notation.

2.3.3 Prevention of sea pollution by harmful substances carried by sea as cargo in packaged form

2.3.3.1 General

Harmful substances carried as cargo in packaged form are to be properly stowed and secured so as to minimize the hazards to the marine environment, according to MARPOL 73/78 Annex III, as amended.

2.3.3.2 Stowage

a) Harmful substances are to be properly stowed and secured so as to minimize the hazards to the marine environment without impairing the safety of the ship and persons on board.

b) Certain harmful substances may, for sound scientific and technical reasons, need to be prohibited for carriage or be limited as to the quantity which may be carried aboard any one ship. In limiting the quantity, due consideration is to be given to the size, construction and equipment of the ship, as well as the packaging and the inherent nature of the substances.

c) Each ship carrying harmful substances is to have a special list or manifest setting forth the harmful substances on board and the location thereof. A detailed stowage plan which sets out the location of the harmful substances on board may be used in place of such special list or manifest.

2.3.3.3 Empty packages

Empty packages which have been used previously for the carriage of harmful substances are themselves to be treated as harmful substances, unless adequate precautions have been taken to ensure that they contain no residue that is harmful to the marine environment.

2.3.3.4 Marking

a) Packages containing harmful substances are to be marked suitably with the correct technical name (trade names alone are not to be used) and, additionally, are to be durably marked or labeled to indicate that the substance is a marine pollutant. Such identification is to be supplemented where possible by other means, for example, by use of the relevant United Nations number.

b) The method of marking the correct technical name and of affixing labels on packages containing a harmful substance is to be such that this information will still be identifiable on packages surviving at least three months' immersion in the sea. In considering suitable marking and labeling, account is to be taken of the durability of the materials used and of the surface of the package.

c) Packages containing small quantities of harmful substances may be exempted from the marking requirements.

2.3.3.5 Leaks

a) Jettisoning of harmful substances carried in packaged form is not permitted, except where necessary for the purpose of ensuring the safety of the ship or saving life at sea.

b) Appropriate measures based on the physical, chemical and biological properties of harmful substances are to be taken to regulate the washing of leakages overboard, provided that compliance with such measures would not impair the safety of the ship and persons on board.

2.3.3.6 Procedures

The Ship Environmental Management Plan referred in 2.4 is to include procedures addressing the requirements of this item.

2.3.4 Prevention of sea pollution by sewage

2.3.4.1 General

Provided the ship has been given a valid ISPP Certificate issued by an Administration or by a recognized organization on behalf of an Administration, in accordance with MARPOL 73/78 Annex IV, as applicable, the additional specific requirements as per 2.3.4.2 to 2.3.4.4 are to be complied with.

2.3.4.2 Discharge of sewage at sea

All sewage discharges whether to sea or shore based facilities are to be recorded in the sewage record book with indication of the date, location and quantity of sewage discharged and are to comply with MARPOL Annex IV discharge requirements.

2.3.4.3 Sewage treatment plant

a) A sewage treatment plant, meeting operational requirements based on the standards and test methods as detailed in Resolution MEPC.2 (VI), as amended, is to be installed on board.

b) The ship is to be equipped with holding tank(s) for treated sewage with sufficient capacity to allow storage of treated sewage when in port or in no discharge areas. The minimum total capacity of such tank(s) is to be 2 days based on the maximum number of persons on board and 96 litres/person/day if a conventional system is used and 11 litres/person/day if a vacuum system is used.

A smaller volume, in any case not lower than 50% of the above capacity, may be accepted provided that:

- The ship is equipped with a post-treatment system for sewage, able to reduce the volume of the effluent (ex. By recycling part of the treated sewage water for on board use);
- 2 days retention is ensured;
- Technical documentation, including results of onboard tests, of the system's efficiency and of effluent volume reduction is documented to the satisfaction of IRS.

c) The ship is to be equipped with a pipe leading to the exterior convenient for the discharge of sewage to a reception facility; such pipe is to be fitted with a standard shore connection in compliance with MARPOL Annex IV, and the materials, piping, fittings and equipment are to comply with the applicable requirements of the various Sections of these Rules.

d) Treated sewage holding tanks are to be equipped with high level alarms.

2.3.4.4 Procedures

The Ship Environmental Management Plan referred to in 2.4 is to include procedures covering the following:

- Sewage management including discharge criteria and use of holding tanks in port and no discharge areas;
- Preparation, filling in and maintenance of the sewage record book;
- Only for passenger and ro-ro passenger ships, periodical analysis, at least every 6 months, of samples of the effluent to verify compliance with IMO Resolution MEPC 159(55) the results of such analysis are to be included in the sewage record book and made available during periodical surveys. The analysis is to be performed by an approved test laboratory ;
- Disposal of sewage treatment plant residues.
  If the ship is not in a condition to dispose at sea of sewage treatment plant residues in accordance with international or national regulations, such residues are to be disposed of ashore or by incineration.

2.3.5 Prevention of sea pollution by garbage

2.3.5.1 General

The applicable requirements of MARPOL 73/78 Annex V, as amended, are to be complied with, in addition to the following additional specific requirements.

2.3.5.2 Placards, garbage management plans and garbage record-keeping

a) Placards which notify the crew and passengers of the disposal requirements of MARPOL Annex V are to be fitted on board as applicable.

b) The placards are to be written in the official language of the State whose flag the ship is entitled to fly and, for ships engaged in voyages to ports or offshore terminals under the jurisdiction of other States, in English or French or Spanish

c) A garbage management plan and record book is to be available on board. This plan is to provide written procedures for collecting, storing, processing and disposing of garbage, including the use of the equipment on board. It is also to designate the person in charge of carrying out the plan. Such plan is to be in accordance with the guidelines in Appendix 1 and written in the working langue of the crew.

d) For passenger ships, special consideration in the garbage management plan is to be given to the following potentially hazardous wastes:

- Photographic and x-ray development fluids
- Dry-cleaning solvents and waste fluids
- Print shop fluids
- Photocopying and laser printer cartridges
- Unused pharmaceuticals and those which are past their use-by-date
- Batteries
- Fluorescent and Mercury vapor lamp bulbs.

2.3.5.3 Waste recycling

For passenger ships other than ro-ro passenger ships:

a) a strategy of waste recycling is to be foreseen, adopted and documented;

b) the minimum total quantity of wastes landed for recycling (Wr) is to be 50% of recyclable wastes produced on board (Wb), where Wb = 40 Kg/person/year based on the number of persons the ship is certified to carry.

The amount of waste landed for recycling is to be recorded in the garbage record book and different wastes are to be collected and landed separately.

Fore the purpose of this Rule, recyclable wastes are:

- Plastic
- Aluminum
- Glass
- Paper-cardboard.

2.3.5.4 Procedures

The Ship Environmental Management Plan referred to in 2.4 is to include procedures covering the Garbage management and waste recycling, according to 2.3.5.

2.3.6 Prevention of sea pollution by other sources

2.3.6.1 Transfer of harmful aquatic organisms and pathogens through ballast water

A ballast water management plan, including a ballast water record book, is to be developed in accordance with IMO Res. A.868 (20), as amended and used for ballast water management.

Unless stricter requirements are enforced by the Port State, it is recommended that ballast water exchange is carried out during international voyages at not less than 200 miles form the nearest land or, if not possible, at not less than 50 miles from nearest land in a zone with water depth not less than 200 [m]. The ship is not to be required to deviate from its intended voyage, or delay the voyage in order to comply with these requirements.

Systems for the treatment of ballast water may be accepted in place of the ballast water exchange, subject to consideration by IRS.

2.3.6.2 Antifouling system

a) Antifouling systems for the hull are to be of TBT-free type.

b) The AFS Certificate and documentation of the TBT-free antifouling system are to be kept on board for checking during periodical surveys.

2.3.6.3 Release of grey water

The requirements of this item apply only to passenger and ro-ro passenger ships

a) Ships are to be equipped with holding tank(s) for grey water with sufficient capacity to allow storage of grey water when in port for at least 2 days. The total capacity of grey water holding tanks is to be based on the maximum number of persons on board and 200 litre/person/day.

b) Grey water holding tanks are to be equipped with high level alarms.

c) If the same tanks are used to hold treated sewage and grey water, their capacity is to be at least the sum of the capacities for the treated sewage holding tanks in 2.3.4.3 and the tanks for grey water.

   A smaller volume, in any case not lower than 50% of the above capacity, may be accepted provided that:

   - The ship is equipped with a system for treating grey-water, able to reduce the volume of the effluent (e.g. by recycling part of the treated grey water for on board use);
   - 2 days retention is ensured;
   - Technical documentation, including results of onboard tests, of the system’s efficiency and of effluent volume reduction is documented to the satisfaction of IRS.

d) The discharging criteria do not apply when the discharge of grey water is necessary for securing the safety of the ship and those on board, or saving life at sea, or when the discharge results from damage to the ship or its equipment.

e) All grey water discharges whether to sea or shore base facilities are to be recorded in the grey water record book with indication of the date, location and quantity of grey water discharged. If the grey water is discharged to sea, the records are to include information on distance to the nearest land.

2.3.6.4 Procedures

The Ship Environmental Management Plan referred to in 2.4 is to include procedures required in 2.3.6 including the grey water discharge criteria and use of holding tanks in ports and in no discharge areas.

2.4 Ship Environmental Management Plan

An Environmental Management Plan, specific to the ship, is to be developed and made available on board.

The Manual is to contain at least the procedures required as per 2.3.1.4, 2.3.3.6, 2.3.4.4, 2.3.5.4 and 2.3.6.4 and is to include:

- The officer/s in charge for carrying out each procedure.
- Documents and manuals required
- Log-books/records to be filled in
- Time schedule when applicable (e.g. checking, sampling, etc.)

The Ship Environmental Management Plan is to be submitted to IRS for information.

2.5 Inspections and Tests

2.5.1 Inspections and testing during construction

2.5.1.1. Materials

Materials for piping and equipment which are used for the construction of equipment and systems to be installed on board in connection with the requirements of this section are to be tested in accordance with the sections of the Rules applicable to similar types of piping or equipment and their class and/or design conditions.

2.5.2 Tests and inspection during fabrication

Piping and equipment relative to the means for preventing sea pollution, as stated in this section, are to be inspected and tested during fabrication in accordance with the sections of the rules applicable to the type of piping or equipment and the relevant class and/or design conditions.

2.5.3 Inspection and testing after installation onboard

2.5.3.1 After installation on board, the equipment and systems installed in connection with the requirements of this section are to be tested in the presence of the Surveyor under operating conditions. The control, monitoring and alarm system are also to be tested in the presence of the Surveyor or their functioning is to be simulated by a procedure agreed with IRS.

Section 3

Clean Air Notation

3.1 Application

3.1.1 This section gives the requirements applicable for the assignment of the notation CLEAN-AIR

3.2 Scope

3.2.1

a) The notation CLEAN-AIR is assigned to ships fitted with efficient means to control and prevent the emission of polluting substances in the air, in accordance with Pt. 1, Ch.1.

b) The requirements of this section are intended to prevent air pollution from any of the following hazards in addition to those stipulated by MARPOL 73/78 Annex VI:

- Emissions of ozone depleting substances
- Emissions contributing to global warming
- Emissions of nitrogen oxides (NO_x)
- Incinerators

In order for the notation CLEAN-AIR to be assigned, all the above polluting hazards are to be considered and the ship is to be fitted with means and/or operational measures to simultaneously prevent all those which are applicable, in relation to its characteristics and the likelihood of producing any or all of such emissions.

3.3 Additional requirements for oil tankers, chemical tankers and gas carriers

3.3.1 A ship which is classed with one or more of the following class notations:

- Oil tanker
- Chemical tanker
- Liquefied gas carrier
- Ore Or Oil Carrier
- Oil or Bulk Carrier
  is also to comply with the requirements of Part 5, Ch 29, in respect of prevention of vapour emissions.

  The assignment of VCS1 or VCS2 notation is prerequisite for assigning the notation CLEAN-AIR.

3.4 Definitions

3.4.1 Ozone Depleting Substances.

Ozone depleting substances are those substances, which are defined in paragraph 4 of Article 1 of the Montreal Protocol on Substances that Deplete the Ozone Layer, 1987, listed in Annexes A, B, C, or E to the Protocol in force at the time of the application of these Rules.

In general, the following ozone depleting substances are used on ships; however, this list is not to be considered comprehensive of all ozone depleting substances that for any reason may be found in a ship.

- Halon 1211– Bromochloridefluoromethane
- Halon 1301 – Bromotrifluromethane
- Halon 2402
- Halon 114B2 – 1,2-Dibromo-1,1,2,1-tetrafluoroethane
- CFC-11 – trichlorofluoromethane
- CFC-12 – Dichlorodicluoromethane
- CFC-113 – Trichloro-1,2,2-trifluoroethane
- CFC-114 – 1,2-Dichloro-1,1,2,2,-tetrafluoroethane
- CFC-115 – Chloropentafluoroethane.

3.4.2 Shipboard incineration

Shipboard incineration is the incineration of wastes or other matter on board a ship, if such wastes or other matter are generated during the normal operation of that ship.

3.4.3 Ozone depleting potential

Ozone depleting potential (ODP) is the potential of ozone depletion compared to CFC-11. Values of ODP for ozone depleting gasses are provided in the “Montreal Protocol on Substances that Deplete the Ozone Layer”.

Table 3.1 : Documents to be submitted for prevention of emission of ozone depleting substances, incinerators, environment management plan and SOx emissions

No.	A/I	Document
1	I	General arrangements of refrigeration plants
2	A	Scheme of refrigerating plant(s) showing the retention facilities as per 3.5.4
3	A	Data sheets with list of intended refrigerants to be used in the different refrigeration systems and their GWP and ODP
4	I	Refrigerant record book
(1) A = to be submitted for approval in four copies; I = to be submitted for information in duplicate.		
Document for incinerator		
5	I	Copy of type approval certificate of statement of compliance with IMO Res.MEPC 76(40)
6	I	Design data, including at least design pressure and design temperature, as applicable (2)
7	A	Piping diagram (2)
8	I	System for waste supply and in incinerator feeding (2)
9	A	Instrumentation, monitoring, alarm and control systems (2)
10	I	Operating manual
Note: A = to be submitted for approval in four copies; I = to be submitted for information in duplicate. (2) Not required if the incinerator is of an approved type.		

Table 3.1 (Contd.)		
11	I	Ship Environmental Management Plan as per 3.5.6, 3.6.8, 3.8.2, 3.9.1.
Note: I = to be submitted for information in duplicate.		
Documents for Sox emissions		
12	A	Detailed plans of systems and equipment to limit SOx emission in the SOx emission control areas (2)
13	A	Ship SOx Environmental Management Plan
Note: A = to be submitted for approval in four copies; (2) Only if such systems and equipment are installed.		

3.4.4 Global warming potential

Global warming potential (GWP) is the potential global warming of a gas compared with CO2 on a time horizon of 100 years. Values of GWP for various refrigerants and gases are published by the US Environmental Protection Agency (EPA).

3.4.5 Documents to be submitted

3.4.6 Table 3.1 lists the documents to be submitted for the assessment of the measures taken to prevent the emission of ozone depleting substances and sulphur oxides

- Requirement of Incinerators
- Preparation of environment management plan

The documents in Table 3.1 are additional to those relative to refrigerating installations and fire-fighting systems listed in the applicable sections of the Rules.

3.5 Emission of ozone depleting substances

3.5.1 Application

a) The following requirements apply to ships with refrigerating facilities, such as refrigerated cargo ships, liquefied gas carriers with reliquefaction plants and other ships with centralized cargo refrigeration systems.

b) They also apply to:

- Centralized refrigeration systems for provision stores
- Centralized air conditioning plants
- Fixed fire-fighting systems.

c) They do not apply to domestic type stand-alone refrigerators and air conditioning units.

3.5.2 Halogenated substances

a) The use of halogenated substances (e.g. Halon and CFC) as refrigerant or fire-fighting means is prohibited, with the exception of hydro-chlorofluorocarbons (HCFCn), which are permitted until 1 January, 2020.

b) Refrigerants of centralized refrigeration systems are to have a global warming potential, GWP < 2000.

3.5.3 Prevention of leakage

a) Means are to be provided to limit leaks to the atmosphere of refrigerants or their vapours in the event of failure of the plant, as well as in the case of discharge of refrigerant to an onshore reception facility.

b) Annual refrigerant leakage is to be less than 10% of the total refrigerant charge of each system. The leakage is to be documented by consumption figures recorded in a refrigerant log-book to be kept on board and made available during periodical surveys.

c) Procedures need to be established such that, in the event that annual leakage exceeds 10%, corrective actions are undertaken.

3.5.4 Evacuation facilities

The system is be fitted with evacuation (e.g. compressors) and retention facilities having the capability to retain all the refrigerants, should the need to evacuate the whole plant arise in an emergency.

3.5.5 Maintenance and servicing

The plant is to be designed in such a way as to minimize the risks of medium release in the case of maintenance, repair or servicing, i.e. it is to be designed considering the possibility of isolating those sections which are to be serviced by a system of valves and bypasses, in such a way as not to stop the operation of the plant while in service, preventing the risk of release of the medium outside of the plant.

3.5.6 Procedures

The Ship Environmental Management Plan, as per 3.9.1 is to contain the following:

- Procedures to be followed to minimize the risk of depleting the refrigerant or the refrigerant vapours in all operative and emergency conditions
- Procedures for preparing, filing and updating the refrigerant log-book.

3.6 Emission of oxides of nitrogen (NOx) from Marine diesel engines

3.6.1 Requirements for emissions from diesel engines apply to all diesel engines with power output in excess of 130 kW, except emergency diesel engines, engines installed in lifeboats and any other device or equipment intended to be used solely in case of emergency.

3.6.2 The maximum allowed total emission levels for marine diesel engines installed onboard shall be as defined in 3.6.3 for NO_x and 3.7.1 and 3.7.2 for SO_x.

3.6.3 NO_x emissions shall comply with the level defined by the IMO NO_x curve, defined by MARPOL 73/78, Annex VI, Reg.13 : Nitrogen Oxide (NO_x). The IMO NO_x curve defines the maximum limits for NO_x per kWh dependent on engine type as identified by engine r.p.m. as given in the following Table 3.2 and Table 3.3.

Table 3.2 : Maximum limits for NO_x per kWh as function of engine r.p.m. (for engines installed on ships constructed prior to 01 Jan 2011)

n < 130 r.p.m	17.0 g/kWh
130 ≤ n < 2000 r.p.m.	45.0 $n^{(-0.2)}$ g/kWh
2000 ≤ n	9.8 g/kWh

Table 3.3 : Maximum limits for NOx per KWh as function of engine rpm (for engines installed on ships constructed on or after 01 Jan 2011)

N < 130 rpm	14.4 g/kwh
130 ≤ n < 2000 rpm	$44n^{(-0.23)}$ g/kwh
2000 ≤ n	7.7 g/kwh

3.6.4 The reduction of oxides of nitrogen can be achieved by the introduction of equipment and arrangements such as, but not limited, to, those listed below:

- Engine adjustments or modifications
- Water addition to the combustion process by water injection, emulsification or humidification
- Exhaust gas cleaning.

3.6.5 All arrangements, fuel oil additives etc. introduced to reduce the NO_x emission levels are subject to IRS approval and shall:

- be operated according to manufacturer's instructions
- allow normal engine performance and safe operation in case of failure
- have features so that its operations and performance can be documented by a log book record
- have sufficient mechanical fastening to ensure safe ad steady support and avoid damaging vibrations
- where applicable, have adequate hatches for inspection and maintenance of installations or systems.

3.6.6 The following arrangements will be subject to special considerations:

- arrangements where NO_x reduction is carried out on more than one engine
- arrangements using SCR cleaning where the reactor unit is positioned between the engine and the turbo blower.

3.6.7 For ships where NO_x emissions are controlled by devices added to the fuel or exhaust systems, such devices shall be operated and controlled in accordance with procedures incorporating the manufacturer instructions and IRS's approval.

Guidance note :

Engine modification and adjustments

NO_x reductions by modification of engine parameters, water injection, fuel emulsification and/or by adjusting engine settings in order to influence the combustion characteristics, should be specified by the engine manufacturer and carried out under his supervision. The chosen combination of modifications and adjustments should aim to avoid an increase in the engine's fuel consumption.

Selective Catalytic Reduction (SCR)

Any requirements related to engine performance where SCR systems are fitted should be identified and addressed in a compliance note to the required documentation as specified in Section 1. The compliance note is also to identify operational temperature limits.

- The reducing agent should be specified by the manufacturer. If other agent than Urea-solution is used, this will be subjected to special considerations.

  In the case where the NO_x emission level is used to verify or control the reduction agent injection rate, the level should be detected by an analyser based upon one of the following methods:

  - Electrochemical cell
  - Infrared chemiluminescene.

NO_x level measurements
NO_x level measurements on engines with NO_x reduction arrangements should comply with methods as decided by IRS.

3.6.8 The Ship Environmental Management Plan is to include as a minimum the following:

a) procedures for periodical checks of the emission related engine parameters and components referred to in the technical file. The periodical checks are to be carried out at least every 6 months and after maintenance or replacement of any such component;

b) procedures of preparing, filing in and updating the engine record book.

c) Methods to control NOx emissions.

d) Means are to be provided to check proper operation of the equipment.

3.7 Emission of oxides of sulphur (SOx)

3.7.1 SO_x emission limits are generally achieved by use of low sulphur content fuel oil. Alternatively, an exhaust gas cleaning system can be adopted in order to obtain the required reductions of SO_x. The maximum sulphur content in fuel oil carried onboard is 3.0%S. Alternatively, SO_x cleaning can be used to achieve a general SO_x content in the exhaust gas of maximum 12.0 g SO_x/kWh.

3.7.2 When in port or in SO_x - controlled areas, the maximum sulphur content in fuel oil used is 1.0%S. Changes of fuel type when entering and leaving port, or SO_x - controlled areas are to be documented by entries in the ship's logbook.

3.7.3 For engines controlling the emission of SO_x through an exhaust gas cleaning system, the SO_x content of the exhaust gas shall be specially considered by IRS.

3.7.4 The sulphur content of any fuel oil used on board ships is not to exceed 4.5% by mass in general and 1.0% while operating in SECA

3.8 Incinerators

3.8.1 Applicability

a) The following requirements apply to ships with a permanently installed shipboard incinerator, generally complying with the requirements of IMO Resolution MEPC.(76)40, adopted on 25 September 1997, “Standard specifications for shipboard incinerators”, which is included in Appendix IV of the NOx Technical Code. Shipboard incinerators described in MARPOL Annex VI, regulation 16(2) are to have IMO type approval certificate for assigning CLEAN-AIR notation.

b) Ships without a permanently installed incinerator, which use the main or auxiliary boilers for incinerating oil sludge generated during normal operations, cannot be assigned CELAN-AIR notation.

3.8.2 Miscellaneous requirements

a) Shipboard incinerators cannot be used to incinerate the following substances:

- Cargo residues of substances indicated in Annexes I, II and III of the IMO International Convention for the Prevention of Pollution from Ships 1973/78, “MARPOL 73/78” as amended and related contaminated packing materials.

- Polychlorinated biphenyl (PCBs)

  - Garbage, as defined in Annex V of “MARPOL 73/78”, containing more than traces of heavy metals.

b) A Manufacturer's operating manual for the incinerator is to be provided on board.

c) Safety measures

1) The flue gas outlet temperature is to be continuously monitored.

2) For incinerators fed continuously by an automatic feeding systems, the waste supply is to be shut off if the temperature indicated above falls below 850°C.

3) For batch loaded incinerators, the unit is to be designed in such a way that the temperature in the combustion chamber reaches 600°C in not less than 5 minutes.

d) The Ship Environmental Management Plan as per 3.9.1 is to address the procedures required as per para a).

3.9 Ship Environmental Management Plan

3.9.1 An Environmental Management Plan, specific to the ship, is to be developed and made available on board.

- The indication of person(s) in charge for each procedure to be carried out
- Documents and manuals required
- Log-books/records to be filled in
- Time schedule when applicable (e.g. periodical checks).

The Ship Environmental Management Plan is to be submitted to IRS for information.

3.10 Inspections and tests

3.10.1 Installations to limit the emission of refrigerants

a) Materials

Materials for piping and equipment specifically designed to limit the emission of refrigerants are to be tested in accordance with the applicable requirements for testing materials intended to be used for the construction of similar types of piping and equipment and their classes and/or design conditions.

b) Tests and inspection during fabrication

Piping and equipment specifically designed to limit the emission of refrigerants are to be inspected and tested during fabrication in accordance with the requirements applicable to similar types of piping or equipment and their classes and/or design conditions.

c) Tests after installation

After installation on board, the plant acceptance trials are to include the operation of the evacuation of all of the refrigerant from the plant to the reception facilities without any release of refrigerant and/or refrigerant vapours. The control, monitoring and alarm systems are also to be tested in the presence of the Surveyor, or their functioning is to be simulated by a procedure agreed with IRS.

3.10.2 Incinerators

The incinerator is to be IMO type approved and after installation function tests as described in operation manual are to be carried out.

3.11 Guidance Note for complying with Sulphur emissions

3.11.1 The sulphur content of any fuel oil used on board ships is not to exceed 4.5% by mass as required by MARPOL 73/78 Annex VI.

3.11.2 Fuel oil management procedures

The ship SOx Environmental Management Plat is to include the following as a minimum:

a) Procedures to detail the maximum sulphur content in the fuel oil purchase orders and to check the actual content of sulphur at the delivery or bunker.

b) Procedures for testing and analysis, in accordance with a recognized standard acceptable to IRS, to be used if the actual sulphur content is checked by sampling.

c) Procedures to manage records of purchase orders, type of checking carried out and results, to be kept on board and made available to the Surveyor.

d) Fuel management procedures to be followed as part of the vessel's certified ship management system.

3.11.3 Navigation in SOx emission control areas

a) Limitation of sulphur emission

Ships are to be provided with effective means to limit the sulphur content of the SOx emission when sailing in SOx emission control areas, as detailed in below

b) Exhaust gas cleaning system

i) An exhaust gas cleaning system is to be provided. This cleaning system is to have the capability to reduce the total emission of sulphur oxides from ships, including both auxiliary and main propulsion engines, to 6.0 g SOx/kWh or less, calculated as the total weight of sulphur dioxide emission.

ii) Waste streams from the use of such equipment are not to be discharged into enclosed ports, harbours and estuaries unless it can be thoroughly documented by the ship that such waste streams have no adverse impact on the ecosystems of such enclosed ports, harbours and estuaries.

3.11.4 Alternative methods

Any other technological method that is verifiable and enforceable to limit SOx emissions to a level equivalent to that indicated above may be considered by IRS on a case-by-case basis.

3.11.4.1 Ships using separate fuel oils

a) The sulphur content of fuel used within SOx emission control areas is not to exceed 1.0% by mass.

b) Ships using separate fuel oils in order to comply with a) above are to allow sufficient time for the fuel oil service system to be fully flushed of all fuels exceeding 1.0% sulphur content prior to entry into an SOx emission control area. The volume of low sulphur fuel oils (equal to or less than 1.0% sulphur content) in each tank as well as the date, time and position of the ship when any fuel changeover operation is completed are to be recorded in the log-book.

3.11.5 Installations to limit the emission of SOx

3.11.5.1 General

If the SOx emission is controlled by an exhaust gas cleaning system, the requirements given below remain applicable.

3.11.5.2 Materials

Materials for piping and equipment which are part of the cleaning system are to be tested in accordance with the requirements applicable to similar types of piping or equipment and their class and/or design conditions.

3.11.5.3 Tests and inspection during fabrication

Piping and equipment are to be inspected and tested during fabrication in accordance with the requirements applicable to the types of piping or equipment which are part of the plant and their class and/or design conditions.

3.11.5.4 Tests after installation

After installation on board, the cleaning system is to be tested in the presence of the Surveyor under operating conditions. The control, monitoring and alarm systems are also to be tested in the presence of the Surveyor or their functioning is to be simulated by a procedure agreed with IRS.

Section 4

Environment Protection (EP) Notation

4.1 General

4.1.1 The notation "EP" (Environmental Protection) will be assigned to vessels complying with the requirements of this section.

4.1.2 The requirements given in section 2 and 3 of Rules are also to be complied with as required for CLEAN-SEA and CLEAN-AIR notations.

4.2 Ship recycling

4.2.1 General

Some of the problems associated with ship recycling might be addressed at the design and construction stage, not only in relation to the ships themselves but also in respect of ships equipment.

The first step is to identify any potentially hazardous materials which might be incorporate, as a matter of routine, in the structure of ships and their equipment and, where practicable, consider using less hazardous alternatives.

4.2.2 Initial stage

The initial stages might include an evaluation of:

a) the type, amount and potential hazard of materials utilized and their location on board a ship;

b) the activities expected during the operation of the ship and any potentially hazardous wastes which might be generated; and

c) the feasibility of addressing the potential for hazardous waste generation by considering:

   1) product reformulation – installing components utilising less potentially hazardous materials;

   2) cleaner production technologies – which generate less waste;

   3) process medication – to generate less waste;

   4) input substitution – utilizing less potentially hazardous consumables or those which generate less waste; and

d) on-site, closed-loop recycling – systems that recycle wastes on board the ship.

4.2.3 Design stage

When designing and constructing a vessel, due account is to be taken of the ship's ultimate disposal, by:

a) using materials which can be recycled safely and in an environmentally sound manner; and

b) minimizing the use of materials known to be potentially hazardous to health and the environment.

4.2.4 Inventory of hazardous materials

In order to contribute towards minimizing potential problems related to protection of the environment in the recycling of vessels, guidelines on ship recycling have been adopted by IMO with resolution A.962(23) to given guidance to all stakeholders in the ship recycling process.

An inventory of hazardous materials is to be developed according to the above mentioned Resolution A.962 (23) – IMO Guidelines on Ship recycling, paragraph 5.

The inventory is a document facilitating the application of these Guidelines providing information with regard to materials known to be potentially hazardous utilized in the construction of the ship its equipment and systems. This is to accompany the ship throughout its operating life. Successive Owners of the ship are to maintain the accuracy of the inventory and incorporate into it all relevant design and equipment changes, with the final Owner delivering the document, with the ship, to the recycling facility.

4.3 Documents to be submitted

a) Table 4.1 lists the plans and documents to be submitted.

b) Table 4.2 lists the procedures and record books to be submitted.

Table 4.1 : Documents to be submitted

No.	A/ I	Document
1	I	Copy of the NLS or ICOF Certificate, if applicable
2	I	Copy of IOPP Certificate
3	A	Drawings of the bilge system including volume of the bilge holding tank (4)
4	I	Copy of the type approval certificate of the oil filtering equipment and alarm
5	A	Schematic arrangement of the fuel oil, lubricating oil and relevant overflow system containing the information necessary to verify the requirements of 2.3.1.3 (4)
6	I	Copy of the approved SOPEP plan including the list of emergency equipment
7	I	Details of enrolment in an Emergency Response Service
8	I	Copy of the ISPP Certificate and copy of the sewage treatment plant type approval certificate

Table 4.1 : (Contd.)

No.	A/ I	Document
9	A	Drawings of the sewage system including piping, holding tank for treated sewage and alarms (4)
10	A	Calculation of volume of holding tank for treated sewage (4)
11	I	Copy of the AFS Certificate or statement of compliance
12	A	Drawings of the grey-water system including piping, holding tank and alarms (1) (4)
13	A	Calculation of volume of grey water holding tank (1) (4)
14	A	Data sheets with the list of refrigerants and fixed fire-fighting means used, their quantity and GWP values (4)
15	A	Details of plans of systems and equipment to limit SOx emissions in SOx emission control areas (2) (4)
16	A	Drawings of fuel oil system, arrangements and procedures for use of separate fuel oil according to requirements given in 3.11 (4)
17	I	Incinerator type approval certificate (2)
18	I	Documentation of compliance with technical requirements for the class notation VCS (3)
19	I	Copy of the EIAPP Certificate or statement of compliance for each engine detailed in 3.6 issued by a recognized organization, as applicable
20	A	Engine Technical File and record book for each engine detailed in 3.6.
21	A	Details and operating manual(s) of NOx control equipment referred to in 3.6 (2)
22	I	General arrangement plan with indication of the zone intended for the stowage of the harmful packaged substances in relation to the other zones of the ship
23	I	Plans of systems and equipment to discharge the harmful substances in case of emergency and to dispose of and wash possible leaks

(1) Passenger ships only
(2) Only if such a system is installed on board
(3) Only ships having service notation according to 3.3
(4) For ships in service, alternative documentation may be accepted provided it is sufficient for the execution of the initial survey

Note : A = to be submitted for approval in four copies
I = to be submitted for information in duplicate.

Table 4.2 : Operational Procedures and Record Books

No.	A/ I	Document
1	I	Oil systems record book
2	I	Sewage record book
3	A	Garbage management plan including garbage record book
4	A	Ballast water management plan including ballast water record book
5	I	Grey water record book (2)
6	I	Refrigerant log book and procedures as per 3.5
7	I	Oily wastes management procedures according to 2.3.1.4b)
8	I	Accidental oil discharge management procedures according to 2.3.1.4b)
9	I	Sewage management procedures according to 2.3.4.4

Table 4.2 (Contd.)

10	I	Garbage management and waste recycling procedures according to 2.3.5[(1)]
11	I	Grey water management procedures according to 2.3.5[(2)]
12	I	Ship Environmental Management Plan
13	I	Fuel management procedures for controlling SOx
14	I	Incinerator management procedures according to 3.8
15	A	Inventory of Hazardous materials according to 4.2.4

(1) Only for passenger ships other than ro-ro passenger ships
(2) Only for passenger ships and ro-ro passenger ships
Note : A – to be submitted for approval in four copies
I – to be submitted for information in 2 copies.

4.4 Inspections, tests and surveys

4.4.1 Inspections and testing during construction

Materials, systems or equipment which are installed on board or modified in order to comply with the requirements of this Section 3 are to be surveyed and tested according to the applicable Rules of IRS.

4.4.2 Initial survey

Following the satisfactory review and approval of the plans and other documentation detailed in 4.2, an initial survey is to be carried out on board in order to:

- Verify that hull and machinery arrangements are in accordance with the approved documentation;
- Test, in the presence of the Surveyor and under working conditions, the equipment and systems covered by these Rules including their control, monitoring and alarms;
- Verify and presence on board of the Ship Environmental Manager;
- Verify the presence on board of the certificates, record and log-books, and Environmental Management Plan requested by these Rules;
- Carry out the engine parameter check according to the engine technical file, of the engines;
- For existing ships, assess and document the satisfactory maintenance of equipment and systems.

End of Chapter

Chapter 31

Integrated Bridge System

Contents

Section 1

General

1.1 Application

1.1.1 Additional class notation will be assigned to ships fitted with Integrated bridge management system which allows simplified and centralized bridge operation of the main functions of Navigation, communication and manouvering of the vessel including monitoring of such critical systems.

1.1.2 Ships fitted with integrated bridge system complying with the requirements of this chapter will be eligible to be assigned additional class notation ‘IBS’.

1.2 Functional requirement

1.2.1 Following functions are to be carried out from the integrated bridge system

- Passage execution
- Communication system
- Monitoring of machinery installations
- Pollution monitoring
- Monitoring of HVAC for passenger ships
- Monitoring of specific cargo operations
- Safety and security

1.3 Reference standards and IMO regulations

1.3.1 IEC 60945:1996, Maritime navigation and radio-communication equipment and systems – General requirements – Methods of testing and required test results.

IEC:61162 (all parts) Maritime navigation and radio-communication equipment and systems – Digital interfaces.

ISO 8468:1990 – Ship’s bridge layout and associated equipment – requirements and guidelines.

IMO International Convention for the Safety of Life at Sea (SOLAS), as amended.

IMO A.823(19) – Performance standards for automatic radar plotting aids (ARPAs).

IMO A.830(19) – Code on alarms and indicators (amendments to IMO 686:1991).

IMO A.694(17) – General requirements for shipborne radio equipment forming part of the global maritime distress and safety system (GMDSS) and for electronic navigational aids.

IMO MSC.64(67) – Annex I – Performance standards for integrated bridge systems.

IMO MSC.64(67) – Annex 4 – Recommendation on performance standards for radar equipment.

IMO MSC/Circular 566:1991 – Provisional guideline on the conduct of trials in which the officer of the navigational watch acts as the sole lookout in periods of darkness.

1.4 Definitions

1.4.1 Configuration of complete system : all operational functions of the IBS Bridge as installed.

1.4.2 Configuration available : operation(s) allocated to and available at each workstation.

1.4.3 Configuration in use : operation(s) and task(s) currently in use at each workstation.

1.4.4 Connectivity : a complete data link and the presence of valid data.

1.4.5 Essential functions : functions related to determination, execution and maintenance of safe course, speed and position of the ship in relation to the waters, traffic and weather conditions.

Such functions include but are not limited to:

- Route planning
- Navigation
- Collision avoidance
- Manoeuvring
- Docking
- Monitoring of internal safety systems
- External and internal communication related to safety in bridge operation and distress situations.

1.4.6 Essential information : that information which is necessary for the monitoring of essential functions.

1.4.7 Functionality: ability to perform an intended function. The performance of a function normally involves a system of displays and instrumentation.

1.4.8 Statutory requirements : IMO Conventions, Regulations, Resolutions, Codes, Recommendations, Guidelines, Circulars and related ISO and IEC standards.

1.4.9 Integrated bridge system (IBS) : any combination of systems which are interconnected in order to allow centralized access to sensor information from workstations to perform two or more of the following operations:

- Passage execution
- Communications
- Machinery monitoring
- Loading, discharging and cargo monitoring
- HVAC monitoring for passenger ships.

1.4.10 Integrity : ability of a system to provide users with accurate, timely, complete and unambiguous information and warnings within a specified time when the system is not in use.

1.4.11 Latency : time interval between an event and the resulting information, including time for processing, transmission and reception.

1.4.12 Multi-function display: a single visual display unit which can present, either simultaneously or through a series of selectable pages, information from more than one operation of a IBS.

1.4.13 Novel systems or equipment: systems or equipment which embody new features not fully covered by provisions of SOLAS V but which provide at least equivalent standard of safety (SOLAS Regulation 19.6).

1.4.14 Part : individual subsystem, equipment or module.

1.4.15 Performance check : a representative selection of short qualitative tests, to confirm correct operation or essential functions of the IBS.

1.4.16 Sensor : a device which provides information to or is controlled or monitored by the IBS.

1.4.17 Workstation : A position at which one or several tasks, constituting a particular activity, is carried out.

1.4.18 Navigation workstation : A workstation at which the navigator may carry out all tasks relevant for deciding, executing and maintaining course and speed in relation to waters and traffic. The instrumentation and controls at the navigation workstation should allow the navigator to:

- Analyse the traffic situation;
- Monitor position, course, track, speed, time, propeller revolutions and pitch, rudder angle, depth of water, rate of turn and wind speed and direction;
- Alter course and speed;
- Effect internal and external communications;
- Give and receive sound signals;

- Control navigational lights;
- Monitor and acknowledge navigational alarms;
- Confirm his well-being and watch-keeping awareness; and
- Record navigational data.

1.4.19 Main steering position : That part of the navigation workstation where those controls and instrumentation relevant to controlling the ship's course are located.

1.4.20 Conning position : A place on the bridge which is used by navigators when commanding, manoeuvring and controlling a ship.

1.4.21 Voyage planning workstation : A workstation at which the navigator may carry out the following tasks without affecting the actual navigation of the vessel:

- Examine and update charts and other relevant documentation;
- Plan a voyage as a series of waypoints, courses, speeds and turns;
- Calculate an estimated time of arrival at various points on the voyage; and
- Determine and plot the ship's position.

1.5 Abbreviations

1.5.1 Abbreviations used in this Rules and annexes :

AIS	:	Automatic identification system
ARPA	:	Automatic radar plotting aid
DSC	:	Digital selective calling
EGC	:	Enhanced group call
EPIRB	:	Emergency position indicating radio beacon
GMT	:	Greenwich Mean Time
HF	:	High Frequency
INMARSAT	:	International Mobile Satellite Organization
ISO	:	International Standards Organization
ITU-R	:	International Telecommunication Union – radio sector
IBS	:	Integrated Bridge System
ITU-T	:	International Telecommunication Union – telecommunication sector
MARPOL	:	IMO Convention for the prevention of pollution by ships
MEPC	:	Marine Environmental Protection Committee of IMO
MF	:	Medium Frequency
MSC	:	Maritime Safety Committee of IMO
NAV	:	IMO Subcommittee on Safety of Navigation
NAVTEX	:	System for broadcast and reception of maritime safety information
OOW	:	Officer of the watch
r.p.m.	:	Revolutions per minute
UTC	:	Universal coordinated time
VDU	:	Visual display unit
VHF	:	Very high frequency
ECDIS	:	Electronic Chart Display Information System

1.6 Equipment list

1.6.1 The list of equipment required for IBS notation is to be as given in Table 6.1.

Section 2

Documentation

2.1 Documents to be submitted

2.1.1 Relevant plans and data are to be submitted for approval and/or information as follows. Unless indicated otherwise, plans submitted by the shipyard are to be in quadruplicate and those submitted by equipment manufacturers are to be in triplicate.

A complete layout and dimensional details of the bridge area and workstations installed therein. This is to include:

a) Arrangements of windows, including dimensions and angles of inclination, dimensions of frames, height above deck surface of upper and lower edges, type of glass and details of clear view arrangements (wipers, fresh water wash, de-icing / de-misting, sunscreens, etc.)

b) Fields of vision from the bridge workstations, including any blind sectors caused by obstructions outside of the wheelhouse.

c) Location and arrangement of workstations, including dimensions of consoles, layout of instrumentation and controls, handrails, seating, etc.

d) Clearances between floor and ceiling or between floor and the underside of ceiling mounted instruments, throughout the wheelhouse.

e) Arrangements for the general illumination of the bridge and the individual illumination of workstation instruments and controls.

f) Details of wheelhouse ventilation and heating systems.

g) Details of internal communication systems operable from the bridge.

h) Arrangements / details of exterior catwalk in front of bridge windows.

i) Details of non-skid flooring

j) Details of wheelhouse doors, including hold-back arrangements.

k) Location of toilet.

l) Arrangements for drainage of bridge decks.

m) Arrangements / details as to the measures to be taken to minimize hazards to personnel.

2.1.2 A list of navigational equipment. This is to include for each item the manufacturer's name and code number, together with copies of relevant type approval certificates.

2.1.3 A complete operational description of the relevant monitoring systems including a list of alarms and displays. This may be accomplished by means of simplified block diagrams of navigation equipment, internal communication systems and watch monitoring and alarm transfer systems and central alarm panel (where provided) including a list of alarms.

2.1.4 A simplified one-line diagram of power supplies to the bridge equipment, circuit protection ratings and settings, cable sizes, rating of connected loads, detailed description and interactions, etc.

2.1.5 Operating / technical manuals for the installed navigational equipment / systems is to be submitted for information.

2.1.6 Sea trial test schedule.

2.1.7 Details and arrangements of the workstations and systems.

2.1.8 The sea trial program is to include test details of the electronic chart display and information systems (EDCIS) and integrated bridge system (IBS).

Section 3

System Requirements

3.1 General

3.1.1 The IBS is to comply with all applicable IMO requirements as contained in the reference regulations listed in 1.3 or other relevant IEC Standards. Parts executing multiple operations are to meet the requirements specified for each individual function they can control, monitor or perform.

3.1.2 Each part of a IBS are to meet the relevant requirements of IMO Resolution A.694(17) as detailed in IEC 60495.

3.1.3 The integrated bridge system is to be of approved type.

3.2 Integration

The system should provide functional integration meeting the following requirements:

a) The functionality of the IBS should ensure that its operation is at least as effective as for stand-alone equipment.

b) Continuously displayed information should be reduced to the minimum necessary for safe operation of the ship. Supplementary information should be readily accessible.

c) Where multifunction displays and controls are used to perform functions necessary for safe operation of the ship they should be duplicated and interchangeable.

d) It should be possible to display the complete system configuration, the available configuration and the configuration in use.

e) Each part to be integrated should provide details of its operational status and the latency and validity of essential information. Means should be provided within the IBS to make use of this information.

f) An alternative means of operation should be provided for essential functions.

g) An alternative source of essential information should be provided. The IBS should identify loss of either source.

h) The source of information (sensor, result of calculation or manual input) should be displayed continuously or upon request.

3.3 Data Exchange

3.3.1 Interfacing within the IBS is to comply with IEC 61162, as applicable.

3.3.2 Data exchange is to be consistent with safe operation of ship.

3.3.3 The integrity of the data flowing on the network is to be ensured.

3.3.4 A failure in the connectivity is not to affect independent functionality.

3.3.5 The network is to be such that in the event of a single failure between the nodes a clear indication of the failure is available, the sensors and displays on the network continue to operate and the data transmission between them is maintained.

3.4 Failure analysis

3.4.1 A analysis is to be performed and documented.

3.4.2 Parts, functions and connectivity are to be identified.

3.4.3 Possible failures of parts and connectivity associated with essential functions and information are to be identified.

3.4.4 Consequences of failures with respect to operation, function or status of the IBS are to be identified.

3.4.5 Each failure is to be classified with respect to its impact on the IBS taking into account relevant characteristics, such as detectability, diagnosability, testability, replaceability and compensating and operating provisions.

3.4.6 The results of the failure analysis are to confirm the possibility of continued safe operation of the ship.

3.5 Quality Assurance

3.5.1 The IBS is to be designed, developed, produced, installed and serviced by companies certified to ISO 9001:2000.

3.6 Alarm management

3.6.1 The IBS alarm management, as a minimum, is to comply with the requirements of “IRS Type Approval Certification scheme for Electrical Equipment used for Control, Protection, Safety and Internal Communication in Marine Environment”.

3.6.2 Appropriate alarm management on priority and functional groups is to be provided within the IBS.

3.6.3 The number of alarm types and their release are to be kept as low as possible by providing indications for information of lower importance.

3.6.4 Alarms should be displayed so that the alarm reason and resulting functional restrictions can be easily understood. Indications are to be self-explanatory.

3.6.5 Alarms are to be prioritized as follows:

a) emergency alarms : Alarms which indicate that immediate danger to human life or to the ship and its machinery exists and that immediate action is to be taken.

b) Distress ,urgency and safety alarms: Alarms which indicate that a mobile unit or a person is in distress, or the calling station has a very urgent message concerning the safety of the mobile unit or person ,or has an important warning to transmit.

c) Primary alarms : Alarms which indicate a condition that requires prompt attention to prevent an emergency condition as specified in statutory and classification rules and regulations

d) Secondary alarms : Alarms which are not included above

3.6.6 The following alarms are to be provided and included in the centralized alarm system:

- Off-course
- Off-track (where automatic track following is provided)
- Way point approaching, (where automatic track following is provided)
- Position fix inaccurate/lost
- Loss of heading input
- Loss of speed log input
- Equipment or sub-system failure
- Gyro mis-match
- Echo-sounder
- Radar CPA
- Navigational light failure
- Steering gear alarms
- Bridge navigational watch alarm system failure.

The audible alarms at the central panel and the relevant workstation are to be silenced when acknowledged from either location. However, it is to be possible to acknowledge the flickering light and bring to steady state only from the relevant work station.

3.6.7 Manual adjustment of any of the facilities of the integrated bridge system is to reset automatically the watch safety interval timer.

3.7 Power system requirement

3.7.1 Power interruptions and shutdown

3.7.1.1 If subjected to an orderly shut-down, the IBS should, upon turn-on, come to an initial default state.

3.7.1.2 After a power interruption full functionality of the IBS should be available after recovery of all subsystems. The IBS should not increase the recovery time of individual subsystem functions after power restoration.

3.7.1.3 If subjected to a power interruption the IBS should, upon restoration of power, maintain the configuration in use and continue automated operation, as far as practicable. Safety related automatic functions should only be restored upon confirmation by the operator.

3.7.2 Power supply

3.7.2.1 Power supply requirements applying to parts of the IBS as a result of other IMO requirements should remain applicable.

3.7.2.2 The IBS should be supplied:

a) from the main and emergency sources of electrical power with automated changeover through a local distribution board with provision to preclude inadvertent shutdown.

b) from a transitional source of electrical power for a duration of not less than 1 min; and

c) where required, parts of the IBS should also be supplied from a reserve source of electrical power.

d) Uninterrupted power supplies. Each vital item in the IBS is to be connected to an UPS. The UPS shall supply the vital IBS equipment with continuous power during a loss of ship's power for a minimum period of 15 minutes. The UPS shall prevent power transients as ship service power is lost and restored such that no loss of control or mal-operation of the IBS units results from these transitions. Battery charge circuits within each unit are to be capable of re-charging the battery from 40% capacity to 80% capacity within 8 hours. Batteries are to be protected from undercharge and overcharge. Battery charging is to be automatic and shall not affect normal operation.

3.8 Communication systems

3.8.1 A telephone system is to be provided to enable two-way speech communication between the wheelhouse and at least in the following locations:

- machinery control station space;

- emergency steering position in the steering gear compartment;
- master's and navigating officers' cabins, offices, mess and public rooms.

3.8.2 The bridge is to have priority over the system.

3.8.3 A list of extension numbers is to be clearly displayed adjacent to each telephone.

3.9 Temperature control

3.9.1 An adequate air conditioning or mechanical ventilation system, together with sufficient heating according to climatic conditions, is to be provided in order to maintain temperature within 22°C to 30°C and the humidity within the range 20 percent to 60 percent. The discharge of hot or cold air is not to be directed towards bridge personnel. Control of this system is to be provided in the wheelhouse.

3.10 EMI/EMC

3.10.1 Electrical and electronic equipment shall be installed so that electromagnetic interference does not affect the proper functioning of the navigational systems and equipment. Installation of the equipment in accordance with the guidelines and recommendations included in IEC 60533 Electrical and electronic installations in ships – Electromagnetic compatibility or an acceptable equivalent standard would generally be considered to meet the requirement.

Section 4

Operational Requirements

4.1 Human factors

4.1.1 The IBS is to be capable of being operated by personnel holding appropriate certificates.

4.1.2 The man-machine interface (MMI) is to be designed to be easily understood and in a consistent style for all integrated functions.

4.1.3 Operational information is to be presented in a readily understandable format without the need to transpose, compute or translate.

4.1.4 Indications, which may be accompanied by a short low intensity acoustic signal are to occur when:

- An attempt is made to execute an invalid function
- An attempt is made to use invalid information.

4.1.5 If an input error is detected by the system it is to require the operator to correct the error immediately. Messages actuated by an input error are to guide the correct responses, e.g. not simply “Invalid entry”, but “Invalid entry, re-enter set point between 0 to 100”.

4.1.6 Layered menus are to be presented in a way which minimizes the added workload to find and return from the desired functions.

4.1.7 An overview is to be easily available to assist the operator in the use of a multiple page system. Each page is to have a unique identifier.

4.1.8 Where multi-function displays are used, they are to be in colour. Continuously displayed information and functional areas, e.g. menus, are to be presented in a consistent manner.

4.1.9 For actions which may cause unintended results, the IBS is to request confirmation from the operator.

Note 1 : Examples of such actions are:

- Attempting to change position and next waypoint while in track mode steering.

- Attempting to switch on bow thruster when insufficient electrical power is available.

4.1.10 Functions requested by the operator are to be acknowledged or clearly indicated by the IBS on completion.

4.1.11 Default values, where applicable, are to be indicated by the IBS when requesting operator input.

4.1.12 The size, colour and density of text and graphic information presented on a display are to be such that it may be easily read from the normal operator position under all operational lighting conditions. (ref ISO 8468-6.2.3).

4.1.13 Symbols used in mimic diagram are to be standardized throughout the system’s displays.

4.1.14 All information is to be presented on a background providing high contrast and emitting as little light as possible at night.

4.2 Bridge layout

4.2.1 General

a) The bridge shall be designed and arranged with the aim of:

- Facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions.

- Promoting effective and safe bridge resource management.

- Allowing for expeditious, continuous and effective information processing and decision-making by the bridge team and the pilot.

- Preventing or minimizing excessive or unnecessary work and any condition or distraction on the bridge which may cause fatigue or interfere with the vigilance of the bridge team and the pilot.

b) The design of bridges is to be governed by:

- The functions and related tasks to be carried out on the bridge, systems used and methods of task performance.

- The range, layout and location of workstations required for performance of bridge functions

- The fields of vision required for visual observations from each of the workstations.

- Composition of the bridge team and the procedures required for safe operations under all identified conditions.

- The type and range of equipment to be provided for performance of the tasks at the individual workstations and elsewhere on the bridge.

4.2.2 Arrangement

a) The bridge configuration, arrangement of consoles and equipment location are to be such as to enable the officer of the watch to perform navigational tasks and other functions allocated to the bridge, as well as maintain an effective lookout. The following tasks are to be supported:

- Navigation and manoeuvring;
- Monitoring;
- Manual steering;
- Docking;
- Planning;
- Safety;
- Communications; and
- Conning.

b) Equipment and associated displays and indicators are to be sited at clearly defined workstations.

c) Consoles, including the chart table, are to be positioned, so that the instrumentation they contain is mounted in such a manner as to face a person looking forward. As far as practicable, operating surfaces are to be normal to the operator's line of sight.

d) From other workstations within the wheelhouse it is to be possible to monitor the navigation workstation and to maintain an effective lookout.

e) The main access to the bridge is to be by means of an internal stairway. Secondary external access is also to be provided.

f) Clear passage of at least 7000 [mm] width is to be available to allow movement around the bridge with a minimum of inconvenience. Particular attention is to be paid to the following routes which are to be as direct as possible:

- From bridge wing to bridge wing, a clear passage of at least 1200 [mm] in width.
- Between the internal entrance to the bridge and the route as above a clear passage of at least 700 [mm] in width is to be provided.
- Between adjacent workstations, a clear passage of at least 700 [mm] is to be provided.

g) Between the bridge front bulkhead or any consoles and installations placed against the front bulkhead, to any consoles or installations placed away from the bridge front, a clear passage of at least 800 [mm] is to be provided.

h) Space necessary for operating at a workstation is to be considered as part of the workstation and is not to be part of the passageway.

i) The clear height between the wheelhouse deck surface covering and the underside of the deckhead is to be at least 2250 [mm]. The lower edge of deckhead mounted equipment is to be at least 2100 [mm] in open areas, passageways and at standing workstations.

j) Toilet facilities are to be provided on or adjacent to the bridge.

4.3 Lighting

4.3.1 The level of lighting is to enable bridge personnel to perform all bridge tasks, including maintenance and chart and office work, by day and night. Controls, indicators, instruments, keyboards, etc. on the bridge are to be capable of being seen in the dark, either by means of internal lighting within the equipment or the wheelhouse lighting system. A satisfactory level of flexibility within the lighting system is to be available to enable the bridge personnel to adjust the lighting in brightness and direction as required in different areas of the bridge and by the needs of individual instruments and controls.

4.3.2 All illumination and lighting of instruments, keyboards and controls are to be adjustable down to zero, except the lighting of alarm indicators and the controls of dimmers which are to remain readable.

4.4 Field of vision

4.4.1 The requirement of Pt.3, Ch.11, Sec.4, Cl.4.2 is to be complied with.

4.4.2 It is to be possible to observe all objects necessary for navigation, including other traffic and navigation marks, in any direction from inside the wheelhouse. In this respect, there is to be a field of view around the ship of 360° obtained by an observer moving within the confines of the wheelhouse.

4.4.3 The view of the sea surface from the conning position and the navigation workstation is not to be obscured by more than two ship lengths, or 500 [m], whichever is less, forward of the bow to 10° on either side, irrespective of the ship's draught, trim and deck cargo, See Fig.4.4.1.

4.4.4 Blind sectors caused by cargo, cargo gear and other obstructions outside of the wheelhouse forward of the beam obstructing the view of the sea surface as seen from the conning position and the navigation workstation are not to exceed 10° each. The total arc of blind sectors is not to exceed 20° and the clear sector between blind sectors shall be at least 5°. However, in the view described in the preceding paragraph, each individual blind sector is not to exceed 5°.

4.4.5 The horizontal field of vision from the conning position and the navigation workstation is to extend over an arc from more than 22.5° abaft the beam on one side, through forward, to more than 22.5° abaft the beam on the other side, See Fig.4.4.2.

4.4.6 From the main steering position, the field of vision is to extend over an arc from dead ahead to at least 60° on each side, See Fig.4.4.3.

4.4.7 From each bridge wing, the field of vision is to extend over an arc from at least 45° on the opposite bow through dead ahead and then aft to 180° from dead ahead, See Fig.4.4.4.

4.4.8 There is to be a line of sight from the port wing to the starboard wing through the wheelhouse.

4.4.9 The ship's side is to be visible from the bridge wing.

4.4.10 From work stations for functions other than navigation, the field of vision is to enable an effective lookout to be maintained and, in this respect, is to extend at least over an arc from 90° on the port bow, through forward, to 22.5° abaft the beam on the starboard side, See Fig.4.4.5.

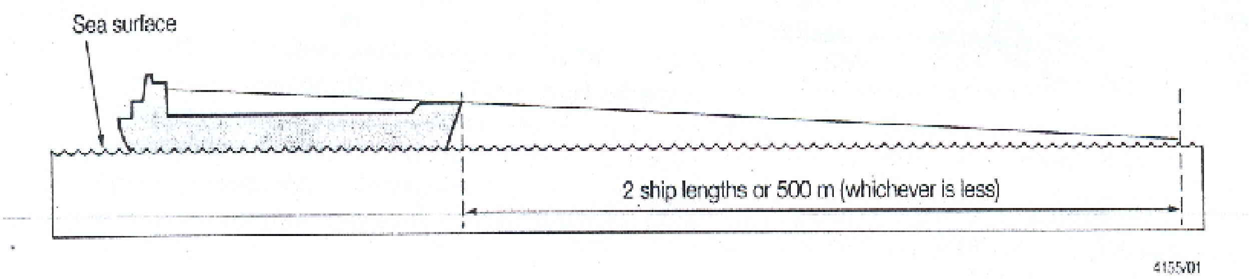


Fig.4.4.1 : View of sea surface from conning position and navigation workstation

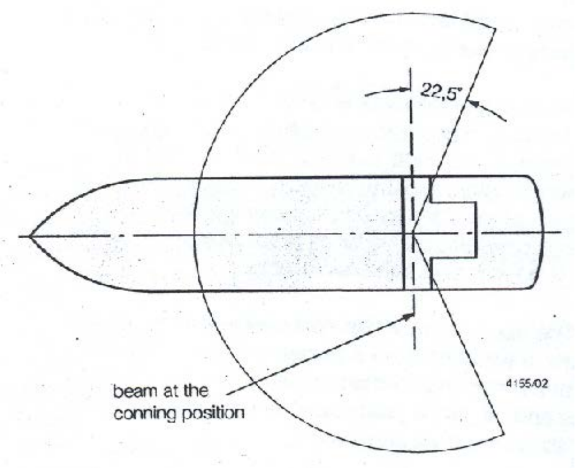


Fig.4.4.2 : Horizontal field of view from conning position and navigation workstation

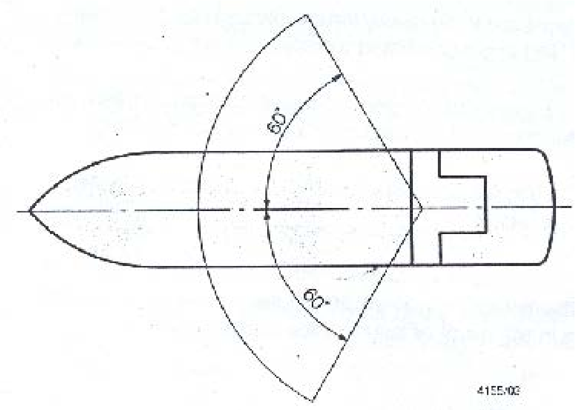


Fig.4.4.3 : Field of view from main steering position

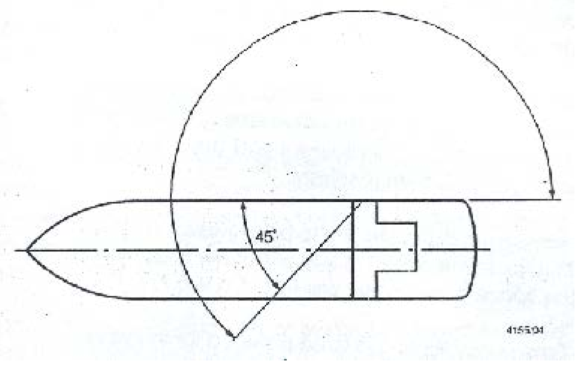


Fig.4.4.4 : Field of view from starboard bridge wing

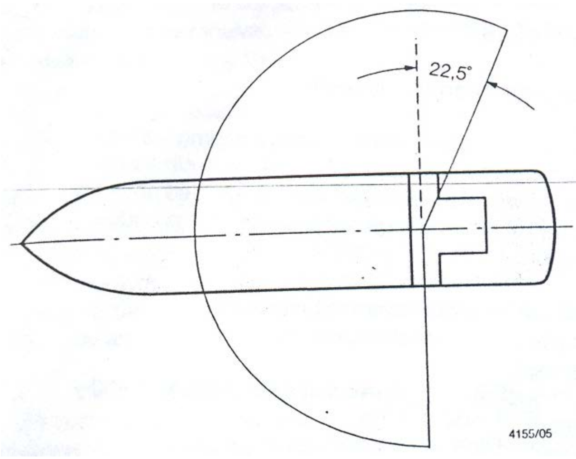


Fig.4.4.5 : Field of view from workstation other than for navigation

4.5 Training

4.5.1 Manufacturers of integrated bridge systems are to provide training facilities for the ship's crew. This training may take place ashore or on board and is to be carried out using suitable material and methods to cover the following topics:

a) General understanding and operation of the system:

- Knowledge and understanding of the system's configuration and application.
- Usage and understanding of the operating manual.
- Usage and understanding of electronic "HELP" functions, if provided in the system.
- Familiarization with the system using safe trial modes.

b) Mastering of uncommon conditions in the system:

- Detecting and locating of failures.
- Resetting the system to safe default values and modes.
- Operating safely without certain sensor data or parts.
- Possibilities for repair on board.
- Identifying the potential for unintended results.

Section 5

Work Station

5.1 General

5.1.1 The bridge and workstation arrangement shall be based on relevant functional requirements and designed in accordance with established principles of ergonomics for safe and efficient operations, enabling the navigator to perceive all relevant information and execute pertinent actions with a minimum workload.

5.1.2 Workstations for additional functions may be located on the bridge provided the performance of such functions does not interfere with the tasks of maintaining safe control of the ship. Workstations for additional functions may include workstations for:

- Extended communication functions
- Monitoring and control of ballasting and cargo operations
- Extended monitoring of machinery
- Remote control of accommodation ladder, hatches and side ports
- Miscellaneous.

5.2 Navigation workstation

5.2.1 A workstation for navigation is to be arranged to enable efficient operation by one person under normal operating conditions. The workstation area is to be sufficient to allow at least two operators to use the equipment simultaneously. The arrangement of instruments and controls is to allow the use of all instruments and controls necessary for navigating and manoeuvring in any normal working position.

5.2.2 An adequate conning position is to be provided close to the forward center window. If the view in the centerline is obstructed by large masts, cranes, etc. two additional conning positions giving a clear view ahead are to be provided, one on the port side and one on the starboard side of the centerline, no more than 5 [m] apart. In addition to the conning position, a second position with a view of the area immediately in front of the bridge superstructure is to be provided close to a forward window or, alternatively, the conning position is to be wide enough to accommodate two persons.

5.2.3 The main steering position is to be located on the ship's centerline, unless the view ahead is obstructed by large masts, cranes, etc. In this case, the steering position is to be located a distance to starboard of the centerline sufficient to obtain a clear view ahead and special steering references for use by day and night are to be provided, e.g. sighting marks forward.

5.2.4 The following facilities are to be provided at the navigation workstation:

- Radar and radar plotting facilities
- Position-fixing system displays
- Echo sounder display
- Speed and distance indications
- Gyrocompass displays
- Magnetic compass display
- Wind speed and direction indication
- Steering controls and indication see Pt.4, Ch.6 and Ch.7
- Rate of turn indication
- Course/track controls and indications
- Main propulsion and thruster controls and indication
- Watch safety system acknowledge
- Watch safety system manual initiation
- Internal communications system
- VHF radiotelephone
- Time indication
- Window clear view controls
- Navigation lights controls
- Whistle control
- Morse light keys
- Wheelhouse/equipment lighting controls
- Automatic ship identification system (AIS) information
- Sound reception system where fitted.

Section 6

Carriage Requirements

6.1.1 The navigation equipment to be carried on board for the performance of various functions are listed in Table 6.1.

6.1.2 Navigational systems and equipment are to be of a type approved by the national administration and in conformity with appropriate performance standards not inferior to those adopted by IMO from time to time. Documentary evidence to this effect is to be submitted. See SOLAS 1974 as amended, Ch.V, Reg.18.

6.1.3 Where alternative means of fulfilling the navigational requirements are permitted, the means are to be approved by the national administration and in conformity with appropriate performance standards.

6.1.4 Two functionally independent radars or alternative means are to be provided to determine and display the range and bearing of radar transponders and other surface craft, obstructions, buoys, shorelines and navigational marks. One of the radars is to operate in the X-band (9 GHz) and the other is to operate in the S-band (3 GHz). Both radars are to include automatic tracking aids to determine collision risks, and at least one radar is to be equipped with an automatic radar plotting aid (ARPA), capable of tracking at least 20 targets, while the other is to be either ARPA or an automatic tracking aid (ATA).

6.1.5 A gyrocompass or alternative means for determining, displaying and transmitting the ship's heading is to be provided. The heading information is to be used directly by the radars, radar plotting aids and automatic identification system. The gyrocompass is to be provided with a gyrocompass heading repeater located at the emergency steering position in the steering gear compartment and gyrocompass bearing repeater(s) allowing bearings to be taken over 360°.

6.1.6 Where automatic track following is provided, sufficient warning is to be given of the approach of a waypoint, so that, in the event of no acknowledgement from the officer of the watch, there is adequate time for the backup navigator to reach the bridge and accept the change of course.

6.1.7 A speed log or alternative means of indicating the ship's speed and distance through water is to be provided. The speed through water measurement is to be used directly by the ARPA as an aid to collision avoidance.

6.1.8 A speed log or alternative means of indicating the ship's speed and distance over ground is to be provided. Speed over ground is to be indicated in both the fore-aft and athwartships directions.

Table 6.1 : Navigational Equipment

Workstation for	Main functions to be performed	Equipment	Remarks
Navigation and traffic surveillance manoeuvering (See Note 1)	• Observation of all vessels and objects	Gyro compass heading indicator	For IBS notation, two independent gyro compasses are to be provided on the bridge
	• Recognizing dangerous situations	Magnetic compass heading indicator	
		Course reminder (set course) indicator	
	• Deciding on collision avoidance actions	Auto pilot / track control system / alternative means	Automatically maintaining ship's heading or a straight track. Immediate restoration of manual control to be possible when required
		Steering gear pump selector switch	
		Steering mode selector switch	
	• Checking vessel's own signal	Steering position indicator	
		Rudder angle indicator	
	• Checking own course and speed	Rate-of-turn indicator and controller	For vessels of 50000 GT or greater
	• Keeping and/or changing own course and speed (track keeping)	Speed and distance indicator	For IBS notation, the speed measuring system is to be independent of the position-fixing systems
		Echosounders with adjustment controls	
	• Checking own position	9 GHz radar and 3 GHz radar	
	• Handling own internal communication on board	Automatic traffic surveillance system including ARPA	

Table 6.1 (Contd.)

Workstation for	Main functions to be performed	Equipment	Remarks
	• Handling communication vessel/vessel and vessel/shore (VHF)	Position fixing equipment/system including automatic visual position indicator	Two types of receivers are to be provided. One of the systems is to be GPS or equivalent and the other GLONASS, or other means such as radar
	• Releasing alarms	Officer of the watch check-alertness acknowledgement device	
	• Perception of group alarms with aids for decision-making	Back-up navigator call alarm device	Two-way communication wireless portable device to be provided
	• Observation of weather and seaway	Facilities for use of navigation charts	This may be separated from the navigation and traffic surveillance/ maneuvering workstation
	• Acknowledging watch check-alertness alarm	Vessel's automatic identification system	
		Voyage data recorder (VDR/S-VDR)	
		Propulsion engines/thrusters controls including emergency stops	Compliance with Part 4, Chapter 4, Section 9 & Part 4, Chapter 7 of the Rules is to be met
	• Keeping deck log (a Dictaphone may be used)	Propulsion engine revolution	If reduction geared engine
		Pitch indicator	For controllable-pitch propeller
		Propeller revolutions indicator	
		Wind direction and velocity indicator	
	• Sounding signals	Air and water temperature and humidity indicator	
		Automatic telephone system	
		Radio-communication/GMDSS equipment	
		NAVTEX automatic receiver and recorder	For navigational and meteorological warning purpose. To comply with IMO Res. A.617(15) – Implementation of the NAVTEX system as a component of the worldwide navigational warning service

Table 6.1 (Contd.)

Workstation for	Main functions to be performed	Equipment	Remarks
		Signal transmitter for: - whistle - automatic device for fog signal - general alarm - morse signaling light	
		Search light controls	
		Controls for windscreen wiper, washer, heater	
		Night vision equipment	
		Sound reception system	If required
		Workstation lighting control device	
		HVAC controls	
		Clock	
		Group alarms and reset controls	
Monitoring (See Note 1)	• Observation of all vessels and objects	Gyro compass heading indicator	For IBS notation, the speed measuring system is to be independent of the position-fixing systems
	• Recognizing dangerous situations	Rudder angle indicator	
	• Handling own internal communication on board	Rate-of-turn indicator	For vessels of 50000 GT or greater
	• Handling communication vessel/ vessel and vessel/shore	Speed and distance indicator	For IBS notation, the speed measuring system is to be independent of the position-fixing systems
	• Perception of group alarms with aids for decision-making	Echosounders	
	• Releasing alarms	9GHz radar and 3 GHz radar	
	• Observation of weather and seaway	Officer of the watch check-alertness acknowledgment device	
	• Acknowledging watch check alertness alarm	Propulsion engines/ thrusters emergency stops	
	• Checking own course and speed	Pitch indicator	For controllable-pitch propeller
	• Keeping deck log	Propeller revolutions indicator	

Table 6.1 (Contd.)

Workstation for	Main functions to be performed	Equipment	Remarks
	• When workstation is occupied by an additional navigator, provides assistance to navigator at the navigation and traffic surveillance/ maneuvering workstation	Automatic telephone system	
	• When workstation is occupied by a pilot advisers to vessel's command	Radio-communication/ GMDSS equipment	
		Signal transmitter for whistle/foghorn	
		Controls for windscreen wiper, washer, heater	
		Workstation lighting control device	
		Clock	

Table 6.1 (Contd.)

Workstation for	Main functions to be performed	Equipment	Remarks
		Required alarms and reset controls	In addition to the alarms/indicators which may be required by the various IMO Resolutions referenced in this chapter and pertinent flag Administration, the following conditions are to be alarmed at the monitoring workstation a) Off-course b) Off-track c) Planned route deviation d) Pre-warning of approach-way point and closest point of approach e) Off-preset water depth f) Gyro compass failure g) Failure of alarms prescribed in 3.6 and section 5 of this Chapter. h) Failure of power supply to distribution panel serving relevant equipment (Alarming of the above conditions at the monitoring workstation is not a substitute for alarming at the required relevant workstations)
Manual steering (Helmsman's) [See Note 1]	• Steering vessel according to rudder angle orders • Steering vessel according to course instruction	Gyro compass heading indicator (repeater)	
		Magnetic compass heading indicator	
		Course reminder (set course) indicator	
		Manual steering with override and selector control switches including steering wheel/steering lever	
	• Steering vessel following landmark / sea marks • Acknowledging watch check alertness alarm	Rudder angle indicator	
		Rate-of-turn indicator	For vessels of 50000 GT or greater
		Watch check-alertness acknowledgement device	
		Automatic telephone system	

Table 6.1 (Contd.)

Workstation for	Main functions to be performed	Equipment	Remarks
		Controls for windscreen wiper, washer, heater	
Docking (Bridge wings)	• Giving instructions, performing and controlling change of course • Giving instructions, performing and controlling change of speed • Giving instructions, performing and controlling change of thruster • Handling communication with maneuvering stations • Handling communication with tugs, pilot boat • Watching water surface along vessel's side • Releasing signals • Acknowledging watch check alertness alarm	Gyro compass heading indicator	
		Steering position selector switch	
		Rudder controls	
		Rudder angle indicator	
		Rate-of-turn indicator	For vessels of 50000 GT or greater
		Propulsion engines/ thrusters controls	
		Propulsion engine revolution	If reduction geared engine
		Pitch indicator	For controllable pitch propeller
		Propeller revolutions indicator	
		Lateral thrust and lateral movement of vessel, indicator	If thrusters are fitted
		Longitudinal movement of vessel, indicator	
		Wind direction and velocity indicator	
		Echosounder	
		Officer of the watch check-alertness acknowledgement device	
		Whistle controls	
		Search light and Morse lamp controls	
		Automatic telephone system	
		Radio-communication/ GMDSS equipment	
		Workstation lighting control device	
Centralized Bridge	As listed in 1.2	Equipment required for the navigation and traffic surveillance / maneuvering and monitoring workstations	
		Central alarm panel	
		ECDIS	

Table 6.1 (Contd.)

Workstation for	Main functions to be performed	Equipment	Remarks
Route Planning	Determination of favourable course and optimum speed, taking into account weather conditions, current, etc. and route planning	ECDIS including navigation planning station	
	Giving instructions as to the course and speed	Route planning devices	
	Calculation of tidal data	Chart table	
	Handling nautical records, documents, publications	Position-fixing receiver	
	Handling weather reports	Retaining device for drawing triangles, dividers, magnifying lens, pencils, etc.	
	Determination of documentation of position in case of conventional operation	Weather chart plotter	
	Control of rate and error of chronometer, deviation, radio deviation, documentation of same	Main clock	
	Keeping deck log	Chronometer with receiving facility for time signals	
	External communication for planning operation using the chart	Log, including distance indicator, course plotter	
		Officer of the watch check-alertness acknowledgement device	
		Barograph	
		Command printer	
		Automatic telephone system	
	Acknowledging watch check alertness alarm	Echosounder	
		Officer of the watch check-alertness acknowledgement device	
		Whistle controls	
		Search light and Morse lamp controls	
		Automatic telephone system	
		Radio-communication/ GMDSS equipment	
		Workstation lighting control device	

Table 6.1 (Contd.)

Note:

1) As the navigation and traffic surveillance / maneuvering, monitoring and manual steering workstations are functionally interrelated and usually installed in close proximity from each other, considerations will be given to the omission of duplicate equipment required at each of the aforementioned workstations.

Section 7

Bridge Navigational Watch Alarm System

7.1 A BNWAS safety system satisfying the requirements of the IMO performance standards for a bridge navigational watch alarm system (BNWAS) and approved by the national administration is to be provided to monitor the well-being and awareness of the watchkeeper. The system is not to cause undue interference with the performance of bridge functions.

7.2 The BNWAS safety system is to automatically become operational whenever the ships heading or track control system is activated.

7.3 The system is to be such that, at a predetermined time, the watchkeeper receives warning that he must indicate his well-being by accepting the warning.

7.4 The time interval between warnings is to be adjustable upto a maximum of 12 minutes.

7.5 It is to be possible to acknowledge the warning at the navigation workstation and at other appropriate locations on the bridge where an effective look-out may be kept. Acknowledgement of any alarm is automatically to reset the time interval between warnings. Manual adjustment of controls may also be used for this purpose.

7.6 Visual warning indications are to be visible and audible warning indications are to be audible, from all operational positions on the bridge where the watchkeeper may reasonably be expected to be stationed. The colour of visual indicators is not to impair night vision.

7.7 In the event that the watchkeeper fails to respond and accept the warning or if any alarm has not been acknowledged on the bridge, within a period of 30 seconds, the system is to immediately initiate a watch alarm to warn the Master and the appointed backup navigator through a fixed installation.

7.8 In the event that the watch alarm is not acknowledged, the system is to initiate the watch alarm at the locations of further crew members capable of taking corrective actions following a time delay sufficient to allow the Master or backup navigator to reach the bridge. The time interval is to be adjustable between 90 seconds upto a maximum of 3 minutes. In ships, other than passenger ships, the watch alarms to warn the further crew members may be initiated at the same time as the watch alarm to warn the Master and backup navigator.

7.9 The watch alarms which sound in the locations of the Master, officers and further crew members capable of taking corrective action should be easily identifiable by its sound and should indicate urgency. The volume of this alarm should be sufficient for it to be heard throughout the locations above and to wake sleeping persons.

7.10 Manual initiation of the watch alarm from the bridge is to be possible at any time.

7.11 The system is to be designed and arranged such that only the ship’s Master has access for enabling and disabling it and setting the appropriate intervals, so as to prevent accidental or unauthorized operation, e.g. removing the fuses or keeping the acknowledgement button permanently depressed either accidentally or deliberately.

7.12 The fixed installation is to be connected to the Master’s and navigating officers’ cabins, offices, mess and public rooms.

7.13 Acknowledgement of the watch alarm is only to be possible on the bridge.

7.14 If, depending upon the shipboard work organization, the backup navigator may attend locations not connected to the alarm transfer system, a wireless portable deice is to be provided enabling both the transfer of alarms and two-way speech communication with the bridge. An audible warning from the portable device is to be provided in the event of loss of the wireless link with the bridge. Alternative arrangements will be considered.

7.15 Failure of the watch alarm system is to activate an audible and visual alarm at the centralized alarm system.

Section 8

Tests and Trials

8.1 General

8.1.1 The tests to be carried out as indicated in this section are intended to supplement and not to replace the testing of parts that is required to meet the relevant IMO performance standards. The tests are intended to ensure that when the parts are integrated there is no degradation of their individual functionality.

8.1.2 In all instances the performance standards for parts will form the minimum test requirement for an integrated system .

8.1.3 During trails, navigational equipment and systems are to be tested to the satisfaction of the attending surveyor in accordance with the test program. The test program is to include following systems as minimum:

a) Course information system
b) Automatic steering system
c) Speed measuring system
d) Depth measuring system
e) Radar system
f) Automatic traffic surveillance system
g) Position fixing system
h) Watch monitoring and alarm transfer system
i) Route planning system
j) Vessel’s automatic identification system
k) Sound reception in bridge , if fitted
l) Radio communication system
m) Centralised bridge workstation provided to enable the navigator to perform necessary navigational, monitoring/alarm and communication functions as required for IBS.

8.1.4 The trial program is to include test details of electronic chart display and information system (ECDIS) and integrated bridge system. The system is to be tested to verify that failure of one sub system does not affect any other sub system. In case of failure of integrated navigational system, it is to be possible to operate the primary navigational equipment / systems functions independently.

End of Chapter

Chapter 32

Polar Class

Contents

Section

Section 1

Polar Class Descriptions and Application

1.1 Application

1.1.1 This chapter gives the additional requirements for ships constructed of steel and intended for navigation in ice-infested polar waters, except ice breakers.

Class notations and related requirements for general ice class and those for operation in Northern Baltic are given in Pt.5, Ch.21.

1.1.2 Ships that comply with requirements of this chapter can be considered for a Polar Class notation as listed in Table 1.2.1. If the hull and machinery are constructed such as to comply with the requirements of different polar classes, then both the hull and machinery will be assigned the lower of these classes in the classification certificate. Compliance of the hull or machinery with the requirements of a higher polar class will also to be indicated in the classification certificate or an appendix thereto.

1.2 Polar classes

1.2.1 The Polar Class (PC) notations and descriptions are given in Table 1.2.1. It is the responsibility of the Owner to select an appropriate Polar Class. The descriptions in Table 1.2.1 are intended to guide owners, designers and administrations in selecting an appropriate Polar Class to match the requirements for the ship with its intended voyage or service.

1.2.2 The Polar Class notation is used to convey the differences between classes with respect to operational capability and strength.

1.2.3 Definitions for nomenclature used in Table 1.2.1:

1.2.3.1 First year ice : Sea ice of not more than one winter's growth, thickness 30 [cm] to 2 [m] in general. This is subdivided into thin / medium / thick first year ice as noted below:

Thin first year ice :	First year ice of less than 70 [cm] thickness
Medium first year ice:	First year ice of 70 to 120 [cm] thickness
Thick first year ice:	First year ice of over 120 [cm] thickness

1.2.3.2 Second year ice : Old ice which has survived only one summer's melt, typically thickness upto 2.5 [m].

1.2.3.3 Multi year ice : Old ice upto 3 [m] thick in general, which has survived at least two summer's melt.

Table 1.2.1 : Polar Class Descriptions

Polar Class	Description (based on WMO Sea ice nomenclature; see 1.2.3 for definitions)
PC 1	Year-round operation in all polar waters
PC 2	Year-round operation in moderate multi-year ice conditions
PC 3	Year-round operation in second-year ice which may include multi-year ice inclusions
PC 4	Year-round operation in thick first-year ice which may include old ice inclusions
PC 5	Year-round operation in medium first-year ice which may include old ice inclusions
PC 6	Summer / autumn operation in medium first-year ice which may include old ice inclusions
PC 7	Summer / autumn operation in thin first-year ice which may include old ice inclusions

1.3 Upper and lower ice waterlines

1.3.1 The upper and lower ice waterlines upon which the design of the vessel has been based will be indicated in the classification certificate. The upper ice waterline (UIWL) is defined by the maximum draughts fore, amidships and aft. The lower ice waterline (LIWL) is defined by the minimum draughts fore, amidships and aft.

1.3.2 The lower ice waterline is to be determined with due regard to the vessel's ice-going capability in the ballast loading conditions (e.g. propeller submergence).

Section 2

Structural Requirements

2.1 Application

2.1.1 This section gives the structural requirements to be complied with for assignment of polar class notations defined in Section 1.

2.2 Hull areas

2.2.1 The hull of all polar class ships is divided into areas reflecting the magnitude of the loads that are expected to act upon them. In the longitudinal direction, there are four regions: bow, bow intermediate, midbody and stern. The bow intermediate, midbody and stern regions are further divided in the vertical direction into the bottom, lower and icebelt regions. The extent of each hull area is illustrated in Fig.2.2.1.

2.2.2 Notwithstanding Fig.2.2.1, the boundary between the bow and bow intermediate regions is not to be forward of the intersection point of the line of the stem and the ship baseline.

2.2.3 Notwithstanding Fig.2.2.1, the aft boundary of the bow region need not be more than 0.45L aft of the forward perpendicular (FP).

2.2.4 The boundary between the bottom and lower regions is to be taken at the point where the shell is inclined 7 deg. to the horizontal.

2.2.5 If a ship is intended to operate astern in ice regions, the aft section of the ship is to be designed using the bow and bow intermediate hull area requirements. This will be indicated in the appendix to the classification certificate.

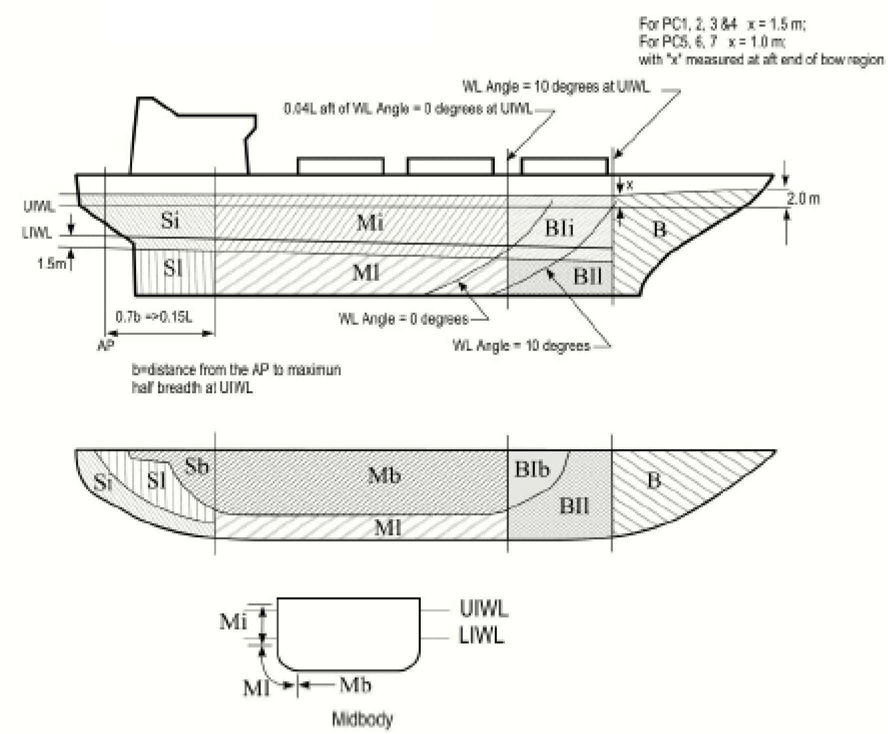


Fig.2.2.1 : Hull area extents

2.3 Design ice loads

2.3.1 General

i) For ships of all polar classes, a glancing impact on the bow is the design scenario for determining the scantlings required to resist ice loads.

ii) The design ice load is characterized by an average pressure (P_{avg}) uniformly distributed over a rectangular load patch of height (b) and width (w).

iii) Within the bow area of all polar classes and within the bow intermediate icebelt area of polar classes PC6 and PC7, the ice load parameters are functions of the actual bow shape. To determine the ice load parameters (P_{avg}, b and w), it is required to calculate the following ice load characteristics for sub-regions of the bow area; shape coefficient (f_{ai}), total glancing impact force (F_i), line load (Q_i) and pressure (P_i).

iv) In other ice-strengthened areas, the ice load parameters (P_{avg}, b_{NONBOW} and w_{NONBOW}) are determined independently of the hull shape and based on a fixed load patch aspect ratio, AR = 3.6.

v) Design ice forces calculated according to 2.3.2 are only valid for vessels with icebreaking forms. Design ice forces for any other bow forms will be specially considered.

vi) Ship structures that are not directly subjected to ice loads may still experience inertial loads of stowed cargo and equipment resulting from ship ice interaction. These inertial loads, based on accelerations will be specially considered.

2.3.2 Glancing impact load characteristics

i) The parameters defining the glancing impact load characteristics are reflected in the class factors listed in Table 2.3.2.

Table 2.3.2 : Class Factors

Polar Class	Crushing failure class factor (CF_C)	Flexural failure class factor (CF_F)	Load patch dimensions class factor (CF_D)	Displacement class factor (CF_{DIS})	Longitudinal strength class factor (CF_L)
PC1	17.69	68.60	2.01	250	7.46
PC2	9.89	46.80	1.75	210	5.46
PC3	6.06	21.17	1.53	180	4.17
PC4	4.50	13.48	1.42	130	3.15
PC5	3.10	9.00	1.31	70	2.50
PC6	2.40	5.49	1.17	40	2.37
PC7	1.80	4.06	1.11	22	1.81

2.3.2.1 Bow area

i) In the bow area, the force (F), line load (Q), pressure (P) and load patch aspect ratio (AR) associated with the glancing impact load scenario are functions of the hull angles measured at the upper ice waterline (UIWL). The influence of the hull angles is captured through calculation of a bow shape coefficient (f_a). The hull angles are defined in Fig.2.3.2.1.

ii) The waterline length of the bow region is generally to be divided into 4 sub-regions of equal length. The force (F), line load (Q), pressure (P) and load patch aspect ratio (AR) are to be calculated with respect to the mid-length position of each sub-region (each maximum of F, Q and P is to be used in the calculation of the ice load parameters P_{avg}, b and w).

iii) The bow area load characteristics are determined as follows:

a) Shape coefficient, fa_i, is to be taken as

fa_i = minimum ($fa_{i,1}$; $fa_{i,2}$; $fa_{i,3}$)

where,

$fa_{i,1} = (0.097 - 0.68\ (x/L - 0.15)^2\ ) \cdot \alpha_i / (\beta'_i)^{0.5}$

$fa_{i,2} = 1.2 \cdot CF_F / (\sin(\beta'_i) \cdot CF_C \cdot \Delta^{0.64})$

$fa_{i,3} = 0.60$

i = sub-region considered

L = rule length as defined in Pt.3, Ch.1, but measured on the upper ice waterline (UIWL) [m]

x = distance from the forward perpendicular (FP) to station under consideration [m]

α = waterline angle [deg], see Fig.2.3.2.1

β' = normal frame angle [deg], see Fig.2.3.2.1

Δ = ship displacement [k-tonnes] , not to be taken less than 5 [k-tonnes]

CF_C = Crushing Failure Class Factor from Table 2.3.2

CF_F = Flexural Failure Class Factor from Table 2.3.2

b) Force, F:

$F_i = fa_i \cdot CF_C \cdot \Delta^{0.64}$ [MN]

where,

i = sub-region considered

fa_i = shape coefficient of sub-region i

CF_C = Crushing Failure Class Factor from Table 2.3.2

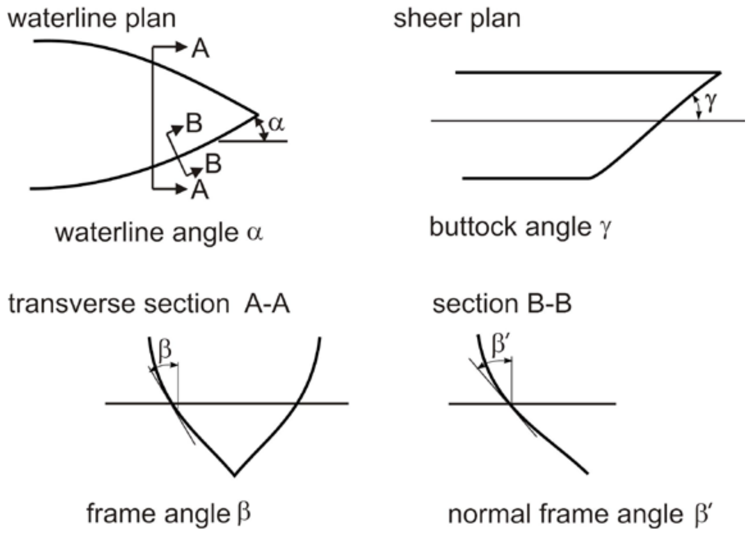
Δ = ship displacement [k-tonnes], not to be taken less than 5 [k-tonnes]

c) Load patch aspect ratio, AR:

$AR_i = 7.46 \cdot \sin(\beta'_i) \geq 1.3$

where,

i = sub-region considered
β'_i = normal frame angle of sub-region i [deg]



Note :

β' = normal frame angle at upper ice waterline [deg]
α = upper ice waterline angle [deg]
γ = buttock angle at upper ice waterline (angle of buttock line measured from horizontal) [deg]
$\tan(\beta) = \tan(\alpha) / \tan(\gamma)$
$\tan(\beta') = \tan(\beta)\cos(\alpha)$

Fig.2.3.2.1 : Definition of hull angles

d) Line load, Q:

$Q_i = F_i^{0.61} . CF_D / AR_i^{0.35}$ [MN/m]

where,

i = sub-region considered
F_i = force of sub-region i [MN]

CF_D = load patch dimensions class factor from Table 2.3.2

AR_i = load patch aspect ratio of sub-region i

e) Pressure, P:

$P_i = F_i^{0.22} . CF_D^2 . AR_i^{0.3}$ [MPa]

where,

i = sub-region considered

F_i = force of sub-region i [MN]

CF_D = load patch dimensions class factor from Table 2.3.2

AR_i = load patch aspect ratio of sub-region i

2.3.2.2 Hull areas other than the bow

In the hull areas other than the bow, the force (F_{NONBOW}) and line load (Q_{NONBOW}) used in the determination of the load patch dimensions (b_{NONBOW}, w_{NONBOW}) and design pressure (P_{avg}) are determined as follows:

a) Force, F_{NONBOW}:

$F_{NONBOW} = 0.36 . CF_C . DF$ [MN]

where,

CF_C = Crushing Force Class Factor from Table 2.3.2

DF = ship displacement factor

$= \Delta^{0.64}$ if $\Delta \le CF_{DIS}$

$= CF_{DIS}^{0.64} + 0.10 (\Delta - CF_{DIS})$ if $\Delta > CF_{DIS}$

Δ = ship displacement [k-tonnes], not to be taken less than 10 [k-tonnes]

CF_{DIS} = Displacement class factor from Table 2.3.2.

b) Line load, Q_{NONBOW}:

$Q_{NONBOW} = 0.639 \cdot F_{NONBOW}^{\,0.61} \cdot CF_D$ [MN/m]

where,

F_{NONBOW} = force from a) above [MN]

CF_D = load patch dimensions class factor from Table 2.3.2.

2.3.3 Design load patch

i) In the bow area of all ships and the bow intermediate icebelt area for ships with class notation PC6 and PC7, the design load patch has dimensions of width, w_{BOW} and height b_{BOW} defined as follows:

$w_{BOW} = F_{BOW} / Q_{BOW}$ [m]

$b_{BOW} = Q_{BOW} / P_{BOW}$ [m]

where,

F_{BOW} = maximum F_i in the bow area from 2.3.2.1(iii)(b) [MN]

Q_{BOW} = maximum Q_i in the bow area from 2.3.2.1(iii)(d) [MN/m]

P_{BOW} = maximum P_i in the bow area from 2.3.2.1(iii)(e) [MPa]

ii) In hull areas other than those covered by i) above, the design load patch has dimensions of width, w_{NONBOW} and height, b_{NONBOW}, defined as follows:

$w_{NONBOW} = F_{NONBOW} / Q_{NONBOW}$ [m]

$b_{NONBOW} = w_{NONBOW} / 3.6$ [m]

where,

F_{NONBOW} = force determined from 2.3.2.2a) [MN]

Q_{NONBOW} = line load determined from 2.3.2.2b) [MN/m]

2.3.4 Pressure within the design load patch

i) The average pressure, P_{avg}, within a design load patch is determined as follows:

$P_{avg} = F / (b \cdot w)$ [MPa]

where,

F = F_{BOW} or F_{NONBOW} as appropriate for the hull area under consideration [MN]

b = b_{BOW} or b_{NONBOW} as appropriate for the hull area under consideration [m]

w = w_{BOW} or w_{NONBOW} as appropriate for the hull area under consideration [m]

ii) Areas of higher, concentrated pressure exist within the load patch. In general, smaller areas have higher local pressures. Accordingly, the peak pressure factors listed in Table 2.3.4 are used to account for the pressure concentration on localized structural members.

Table 2.3.4 : Peak pressure factors

Structural Member		**Peak Pressure Factor (PPF_i)**
Plating	Transversely-framed	$PPF_p = (1.8 - s) \geq 1.2$
	Longitudinally-framed	$PPF_p = (2.2 - 1.2 \cdot s) \geq 1.5$
Frames in transverse framing systems	With load distributing stringers	$PPF_t = (1.6 - s) \geq 1.0$
	With no load distributing stringers	$PPF_t = (1.8 - s) \geq 1.2$
Load carrying stringers, side and bottom longitudinals, web frames		$PPF_s = 1$, if $S_w \geq 0.5 \cdot w$ $PPF_s = 2.0 - 2.0 \cdot S_w / w$, if $S_w < (0.5 \cdot w)$

Table 2.3.4 (Contd.)

where,

s = frame or longitudinal spacing [m]

S_w = web frame spacing [m]

w = ice load patch width [m]

2.3.5 Hull area factors

i) Associated with each hull area is an area factor that reflects the relative magnitude of the load expected in that area. The Area Factor (AF) for each hull area is listed in Table 2.3.5.

ii) In the event that a structural member spans across the boundary of a hull area, the largest hull area factor is to be used in the scantling determination of the member.

iii) Due to their increased manoeuvrability, ships having propulsion arrangements with azimuthing thruster(s) or "podded" propellers shall have specially considered stern icebelt (S_i) and stern lower (S_l) hull area factors.

Table 2.3.5 : Hull area factors (AF)

Hull Area		**Area**	**Polar Class**						
			PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Bow (B)	All	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bow intermediate (BI)	Icebelt	BI_i	0.90	0.85	0.85	0.80	0.80	1.00*	1.00*
	Lower	BI_l	0.70	0.65	0.65	0.60	0.55	0.55	0.50
	Bottom	BI_b	0.55	0.50	0.45	0.40	0.35	0.30	0.25
Midbody (M)	Icebelt	M_i	0.70	0.65	0.55	0.55	0.50	0.45	0.45
	Lower	M_l	0.50	0.45	0.40	0.35	0.30	0.25	0.25
	Bottom	M_b	0.30	0.30	0.25	**	**	**	**
Stern (S)	Icebelt	S_i	0.75	0.70	0.65	0.60	0.50	0.40	0.35
	Lower	S_l	0.45	0.40	0.35	0.30	0.25	0.25	0.25
	Bottom	S_b	0.35	0.35	0.30	0.25	0.15	**	**

Note :

* See 2.3.1 (iii).

** Indicates that strengthening for ice loads is not necessary.

2.4 Shell plate requirements

2.4.1 The required minimum shell plate thickness, t, is given by:

$t = t_{net} + t_s$ [mm]

where,

t_{net} = plate thickness required to resist ice loads according to 2.4.2 [mm]

t_s = corrosion and abrasion allowance according to 2.11 [mm].

2.4.2 The thickness of shell plating required to resist the design ice load, t_{net}, depends on the orientation of the framing.

In the case of transversely-framed plating ($\Omega \geq 70$ deg), including all bottom plating, i.e. plating in hull areas BI_b, M_b and S_b, the net thickness is given by:

$t_{net} = 500 . s . ((AF . PPF_p . P_{avg}) / \sigma_y)^{0.5} / (1 + s / (2 . b))$ [mm]

In case of longitudinally-framed plating ($\Omega \leq 20$ deg), when $b \geq s$, the net thickness is given by:

$t_{net} = 500 . s . ((AF . PPF_p . P_{avg}) / \sigma_y)^{0.5} / (1 + s / (2 . l))$ [mm]

In case of longitudinally-framed plating ($\Omega \leq 20$ deg), when $b < s$, the net thickness is given by:

$t_{net} = 500 . s . ((AF . PPF_p . P_{avg}) / \sigma_y)^{0.5} . (2 . b / s - (b / s)^2)^{0.5} / (1 + s / (2 . l))$ [mm]

In case of obliquely-framed plating (70 deg > Ω > 20 deg), linear interpolation is to be used:

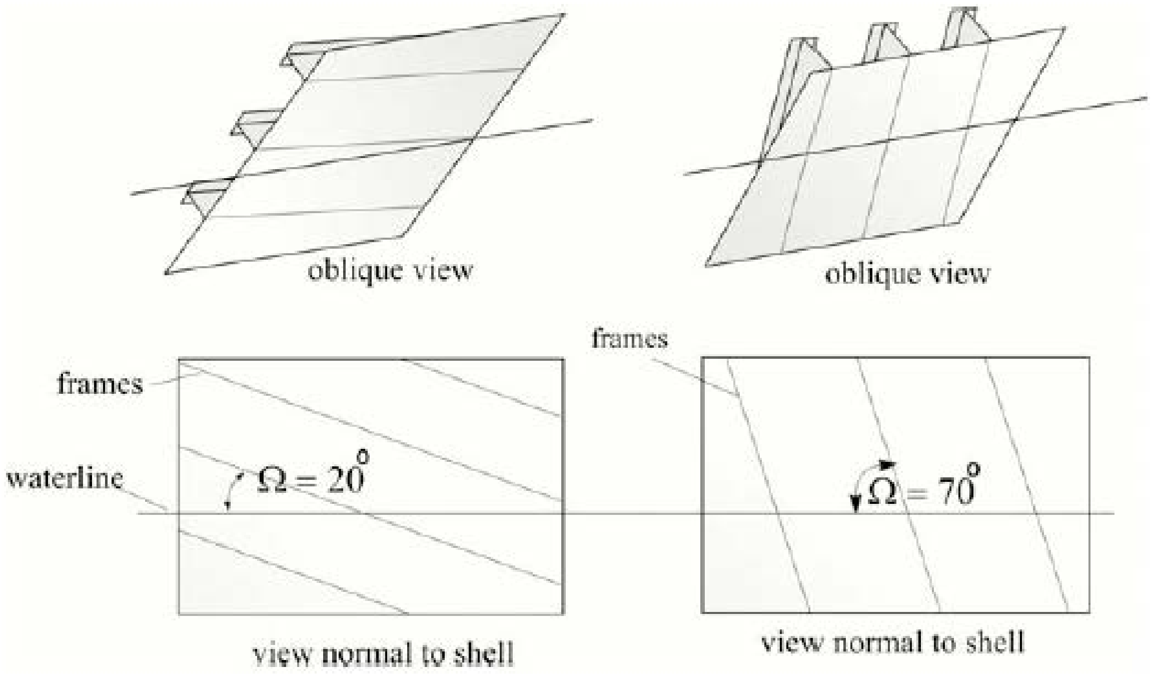


Fig.2.4.2 : Shell framing angle Ω

where,

Ω = smallest angle between the chord of the waterline and the line of the first level framing as illustrated in Fig.2.4.2 [deg.]

s = transverse frame spacing in transversely-framed ships or longitudinal frame spacing in longitudinally-framed ships [m]

AF = Hull area factor from Table 2.3.5

PPF_p = Peak pressure factor from Table 2.3.4

P_{avg} = average patch pressure according to 2.3.4

σ_y = minimum upper yield stress of the material [N/mm^2]

b = height of design load patch [m], where b ≤ (l - s/4) in the case of transverse framing with $\Omega \geq$ 70 deg.

l = distance between frame supports, i.e. equal to the frame span as given in 2.5.5, but not reduced for any fitted end brackets [m]. When a load-distributing stringer is fitted, the length l need not be taken larger than the distance from the stringer to the most distant frame support.

2.5 Framing – General

2.5.1 Framing members of polar class ships are to be designed to withstand the ice loads defined in 2.3.

2.5.2 The term "framing member" refers to transverse and longitudinal local frames, load-carrying stringers and web frames in the areas of the hull exposed to ice pressure, see Fig.2.2.1.

2.5.3 The strength of a framing member is dependent upon the fixity that is provided at its supports. Fixity can be assumed where framing members are either continuous through the support or attached to a supporting section with a connection bracket. In other cases, simple support is to be assumed unless the connection can be demonstrated to provide significant rotational restraint. Fixity is to be ensured at the support of any framing which terminates within an ice-strengthened area.

2.5.4 The details of framing member intersection with other framing members, including plated structures, as well as the details for securing the ends of framing members at supporting sections are to be in accordance with Pt.3, Ch.3.

2.5.5 The design span of a framing member is to be determined on the basis of its moulded length. If brackets are fitted, the design span may be reduced in accordance with Pt.3, Ch.3. Brackets are to be configured to ensure stability in the elastic and post-yield response regions.

2.5.6 When calculating the section modulus and shear area of a framing member, net thicknesses of the web, flange (if fitted) and attached shell plating are to be used. The shear area of a framing member may include that material contained over the full depth of the member, i.e. web area including portion of flange, if fitted, but excluding attached shell plating.

2.5.7 The actual net effective shear area. A_w, of a framing member is given by:

$A_w = h\ t_{wn} \sin \varphi_w / 100$ [cm^2]

h = height of stiffener [mm], see Fig.2.5.7

t_{wn} = net web thickness [mm]

= $t_w - t_c$

t_w = as built web thickness [mm], see Fig.2.5.7

t_c = corrosion deduction [mm] to be subtracted from the web and flange thickness (specified as t_s in 2.11.3, however not less than that given in Pt.3, Ch.3, Sec.2).

φ_w = smallest angle between shell plate and stiffener web, measured at the midspan of the stiffener, see Fig.2.5.7. The angle φ_w may be taken as 90 degrees provided the smallest angle is not less than 75 degrees.

2.5.8 When the cross-sectional area of the attached plate flange exceeds the cross-sectional area of the local frame, the actual net effective plastic section modulus, Z_p, is given by:

$$Z_p = 0.05 A_{pn} . t_{pn} + 0.0005\ h_w^2\ t_{wn} \sin\varphi_w + 0.1 A_{fn} \left(h_{fc} \sin\varphi_w - b_w \cos\varphi_w\right) \quad [\text{cm}^3]$$

h, t_{wn}, t_c and φ_w are as given in 2.5.7 and s as given in 2.4.2

A_{pn} = net cross-sectional area of the local frame [cm^2]

t_{pn} = fitted net shell plate thickness [mm] (shall comply with t_{net} as required by 2.4.2)

h_w = height of local frame web [mm], see Fig.2.5.7

A_{fn} = net cross-sectional area of local frame flange [cm^2]

h_{fc} = height of local frame measured to center of the flange area [mm], see Fig.2.5.7

b_w = distance from mid thickness plane of local frame web to the centre of the flange area [mm], see Fig.2.5.7

When the cross-sectional area of the local frame exceeds the cross-sectional area of the attached plate flange, the plastic neutral axis is located a distance z_{na} above the attached shell plate, given by:

$z_{na} = (100\ A_{fn} + h_w\ t_{wn} - 1000\ t_{pn}\ s) / (2\ t_{wn})$ [mm]

and the net effective plastic section modulus, Z_p, is given by:

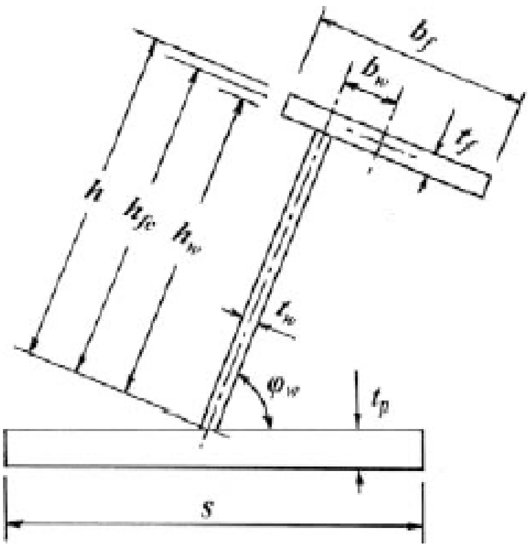


Fig.2.5.7 : Stiffener geometry

$$Z_p = t_{pn}\, s\left[Z_{na} + t_{pn}/2\right]\sin\varphi_w + 0.0005\left(\left(h_w - z_{na}\right)^2 + z_{na}^2\right)t_{wn}\sin\varphi_w + 0.10\,A_{fn}\left(\left(h_{fc} - z_{na}\right)\sin\varphi_w - b_w\cos\varphi_w\right)[cm^3]$$

2.5.9 In the case of oblique framing arrangement (70 deg > Ω > 20 deg, where Ω is defined as given in 2.4.2), linear interpolation is to be used.

2.6 Framing – Transversely framed side structures and bottom structures

2.6.1 The local frames in transversely-framed side structures and in bottom structures (i.e. hull areas BI_b, M_b and S_b) are to be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member. The plastic strength is defined by the magnitude of midspan load that causes the development of a plastic collapse mechanism.

2.6.2 The actual net effective shear area of the frame, A_w, as defined in 2.5.7, is to comply with the following condition: $A_w \geq A_t$, where:

$A_t = 100^2 . 0.5 . LL . s . (AF . PPF_t . P_{avg}) / (0.577 . \sigma_y)$ [cm^2]

where,

LL = length of loaded portion of span

= lesser of a and b [m]

a = frame span as defined in 2.5.5 [m]

b = height of design ice load patch according to 2.3.3(i) or (ii) [m]

s = transverse frame spacing [m]

AF = hull area factor from Table 2.3.5

PPF_t = peak pressure factor from Table 2.3.4

P_{avg} = average pressure within load patch according to 2.3.4 [MPa]

σ_y = minimum upper yield stress of the material [N/mm^2]

2.6.3 The actual net effective plastic section modulus of the plate / stiffener combination, Z_p, as defined in 2.5.8, is to comply with the following condition : $Z_p \geq Z_{pt}$, where Z_{pt} is to be the greater calculated on the basis of two load conditions : a) ice load acting at the midspan of the transverse frame, and b) the ice load acting near a support. The A1 parameter in the following reflects the two conditions:

$Z_{pt} = 100^3 . LL . Y . s . (AF . PPF_t . P_{avg}) . a . A_1 / (4 . \sigma_y)$ [cm^3]

where,

AF, PPF_t, P_{avg}, LL, b, s, a and σ_y are as given in 2.6.2

$Y = 1 – 0.5 . (LL / a)$

A_1 = maximum of

$A_{1A} = 1 / (1 + j / 2 + k_w . j / 2 . [(1 – a_1^2)^{0.5} – 1])$

$A_{1B} = (1 - 1 / (2 . a_1 . Y)) / (0.275 + 1.44 . k_z^{0.7})$

j = 1 for framing with one simple support outside the ice-strengthened areas

= 2 for framing without any simple supports

$a_1 = A_t / A_w$

A_t = minimum shear area of transverse frame as given in 2.6.2 [cm^2]

A_w = effective net shear area of transverse frame (calculated according to 2.5.7) [cm^2]

$k_w = 1 / (1 + 2 . A_{fn} / A_w)$ with A_{fn} as given in 2.5.8

$k_z = z_p / Z_p$ in general

= 0.0 when the frame is arranged with end bracket

z_p = sum of individual plastic section modulii of flange and shell plate as fitted [cm^3]

$= (b_f . t_{fn}^2 / 4 + b_{eff} . t_{pn}^2 / 4) / 1000$

b_f = flange breadth [mm], see Fig.2.5.7

t_{fn} = net flange thickness [mm]

$= t_f – t_c$ (t_c as given in 2.5.7)

t_f = as-built flange thickness [mm], see Fig.2.5.7

t_{pn} = the fitted net shell plate thickness [mm] (not to be less than t_{net} as given in 2.4)

b_{eff} = effective width of shell plate flange [mm]

= 500 s

Z_p = net effective plastic section modulus of transverse frame (calculated according to 2.5.8) [cm^3]

2.6.4 The scantlings of the frame are to meet the structural stability requirements of 2.9.

2.7 Framing – Side longitudinals (longitudinally-framed ships)

2.7.1 Side longitudnals are to be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member. The plastic strength is defined by the magnitude of midspan load that causes the development of a plastic collapse mechanism.

2.7.2 The actual net effective shear area of the frame, A_w, as defined in 2.5.7, is to comply with the following condition: $A_w \geq A_L$, where:

$A_L = 100^2 . (AF . PPF_s . P_{avg}) . 0.5 . b_1 . a / (0.577 . \sigma_y)$ [cm^2]

where,

AF = Hull area factor from Table 2.3.5

PPF_s = Peak pressure factor from Table 2.3.4

P_{avg} = average pressure within load patch according to 2.3.4 [MPa]

$b_1 = k_o . b_2$ [m]

$k_o = 1 – 0.3 / b'$

b' = b / s

b = height of design ice load patch from 2.3.3 i) or ii) [m]

s = spacing of longitudinal frames [m]

b_2 = b (1 – 0.25 . b') [m], if b' < 2

= s [m], if b' ≥ 2

a = design span of longitudinal as given in 2.5.5 [m]

σ_y = minimum upper yield stress of the material [N/mm^2]

2.7.3 The actual net effective plastic section modulus of the plate / stiffener combination, Z_p, as defined in 2.5.8, is to comply with the following condition: $Z_p \geq Z_{pL}$, where:

$Z_{pL} = 100^3 \,.\, (AF \,.\, PPF_s \,.\, P_{avg}) \,.\, b_1 \,.\, a^2 \,.\, A_4 / (8 \,.\, \sigma_y)$ [cm^3]

where,

AF, PPF_s, P_{avg}, b_1, a and σ_y are as given in 2.7.2

$A_4 = 1 / (2 + k_{wl} \,.\, [(1 - a_4^2)^{0.5} - 1])$

$a_4 = A_L / A_w$

A_L = minimum shear area for longitudinal as given in 2.7.2 [cm^2]

A_w = net effective shear area of longitudinal (calculated according to 2.5.7) [cm^2]

$K_{wl} = 1 / (1 + 2 \,.\, A_{fn} / A_w)$ with A_{fn} as given in 2.5.8.

2.7.4 The scantlings of the longitudinals are to meet the structural stability requirements of 2.9.

2.8 Framing – Web frame and load-carrying stringers

2.8.1 Web frames and load-carrying stringers are to be designed to withstand the ice load patch as defined in 2.3. The load patch is to be applied at locations where the capacity of these members under the combined effects of bending and shear is minimized.

2.8.2 Web frames and load-carrying stringers are to be dimensioned such that the combined effects of shear and bending do not exceed the permissible stresses given below:

Shear stress $\tau = \sigma_y / \sqrt{3}$

Bending stress $\sigma_b = \sigma_y$

Equivalent stress $\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = 1.15\sigma_y$

Where these members form part of a structural grillage system, appropriate methods of analysis are to be used. Where the structural configuration is such that members do not form part of a grillage system, the appropriate peak pressure factor (PPF) from Table 2.3.4 is to be used. Special attention is to be paid to the shear capacity in way of lightening holes and cut-outs in way of intersecting members.

2.8.3 The scantlings of web frames and load-carrying stringers are to meet the structural stability requirements of 2.9.

2.9 Framing – structural stability

2.9.1 To prevent local buckling in the web, the ratio of web height (h_w) to net web thickness (t_{wn}) of any framing member is not to exceed:

For flat bar sections:

$$h_w / t_{wn} \leq 282 / (\sigma_y)^{0.5}$$

For bulb, tee and angle sections:

$$h_w / t_{wn} \leq 805 / (\sigma_y)^{0.5}$$

where,

h_w = web height
t_{wn} = net web thickness
σ_y = minimum upper yield stress of the material [N/mm^2]

2.9.2 Framing members for which it is not practicable to meet the requirements of 2.9.1 (e.g. load carrying stringers or deep web frames) are required to have their webs effectively stiffened. The scantlings of the web stiffeners are to ensure the structural stability of the framing member. The minimum net web thickness for these framing members is given by:

$t_{wn} = 2.63 \times 10^{-3} \,.\, c_1 \,.\, (\sigma_y / (5.34 + 4 \,.\, (c_1 / c_2)^2))^{0.5}$ [mm]

where,

$c_1 = h_w - 0.8 \,.\, h$ [mm]

h_w = web height of stringer / web frame [mm] (see Fig.2.9.2)

h = height of framing member penetrating the member under consideration (0 if no such framing member) [mm] (see Fig.2.9.2)

c_2 = spacing between supporting structure oriented perpendicular to the member under consideration [mm] (see Fig.2.9.2)

σ_y = minimum upper yield stress of the material [N/mm^2]

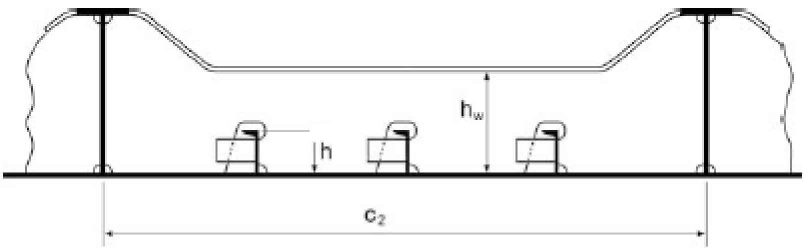


Fig.2.9.2 : Parameter definition for web stiffening

2.9.3 In addition, the following is to be satisfied:

$t_{wn} \geq 0.35 \cdot t_{pn} \cdot (\sigma_y / 235)^{0.5}$

where,

σ_y = minimum upper yield stress of the shell plate in way of the framing member [N/mm^2]

t_{wn} = net thickness of the web [mm]

t_{pn} = net thickness of the shell plate in way of the framing member [mm]

2.9.4 To prevent local flange buckling of welded profiles, the following are to be satisfied:

i) The flange width, b_f [mm], shall not be less than five times the net thickness of the web, t_{wn}.

ii) The flange outstand, b_{out} [mm], shall meet the following requirement:

$b_{out} / t_{fn} \leq 155 / (\sigma_y)^{0.5}$

where,

t_{fn} = net thickness of flange [mm]

σ_y = minimum upper yield stress of the material [N/mm^2].

2.10 Plated structures

2.10.1 Plated structures are those stiffened plate elements in contact with the hull and subject to ice loads e.g. bulkheads, decks etc. These requirements are applicable to an inboard extent which is the lesser of:

i) web height of adjacent parallel web frame or stringer; or

ii) 2.5 times the depth of framing that intersects the plated structure

2.10.2 The thickness of the plating and the scantlings of attached stiffeners are to be such that the degree of end fixity necessary for the shell framing is ensured.

2.10.3 The stability of the plated structure is to adequately withstand the ice loads defined in 2.3.

2.11 Corrosion / abrasion additions

2.11.1 Effective protection against corrosion and ice-induced abrasion is recommended for all external surfaces of the shell plating for all polar ships.

2.11.2 The values of corrosion / abrasion additions, t_s, to be used in determining the shell plate thickness for each polar class are listed in Table 2.11.2.

2.11.3 Polar ships are to have a minimum corrosion addition of t_s = 1.0 [mm] applied to all internal structures within the ice-strengthened hull areas, including plated members adjacent to the shell, as well as stiffener webs and flanges.

Table 2.11.2 : Corrosion / abrasion additions for shell plating						
Hull Area	**t_s [mm]**					
	With effective protection			**Without effective protection**		
	PC1 – PC3	**PC4 and PC5**	**PC6 and PC7**	**PC1 – PC3**	**PC4 and PC5**	**PC6 and PC7**
Bow; bow intermediate icebelt	3.5	2.5	2.0	7.0	5.0	4.0
Bow intermediate lower; midbody and stern icebelt	2.5	2.0	2.0	5.0	4.0	3.0
Midbody and stern lower; bottom	2.0	2.0	2.0	4.0	3.0	2.5

2.12 Materials

2.12.1 Plating material grades for hull structures are to be not less than those given in Tables 2.12.1a) and Table 2.12.1b) based on the as-built thickness of the material, the Polar Ice Class notation assigned to the ship and the material class of structural members given in accordance to 2.12.2.

2.12.2 Material classes specified in Pt.3, Ch.2, Table 2.2.1a) are applicable to polar ships regardless of the ship's length. In addition, material classes for weather and sea exposed structural members and for members attached to the weather and sea exposed shell plating of polar ships are given in Table 2.12.2. Where the material classes in Table 2.12.2 and those in Pt.3, Ch.2, Table 2.2.1a) differ, the higher material class is to be applied.

2.12.3 Steel grades for all plating and attached framing of hull structures and appendages situated below the level of 0.3 [m] below the lower ice waterline, as shown in Fig.2.12.3 are to be obtained from Table 2.2.2 of Pt.3, Ch.2 based on the material class for structural members in Table 2.12.2 above, regardless of Polar Class.

2.12.4 Steel grades for all weather exposed plating of hull structures and appendages situated above the level of 0.3 [m] below the lower ice waterline, as shown in Fig.2.12.3 are to be not less than given in Table 2.12.1a).

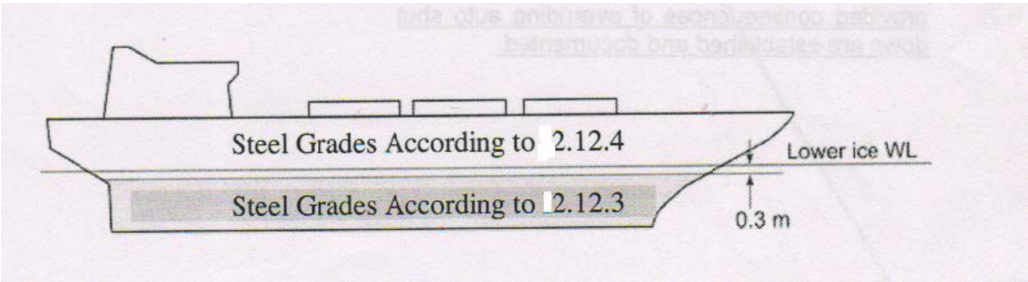


Fig.2.12.3 : Steel grade requirements for submerged and weather exposed shell plating

Table 2.12.2 : Material classes for structural members of polar ships

Structural Members	Material Class
Shell plating within the bow and bow intermediate icebelt hull areas (B, BI_i)	II
All weather and sea exposed SECONDARY and PRIMARY, as defined in Table 2.2.1a) of Pt.3, Ch.2, structural members outside 0.4L amidships	I
Plating materials for stem and stern frames, rudder horn, rudder, propeller nozzle, shaft brackets, ice skeg, ice knife and other appendages subject to ice impact loads	II
All inboard framing members attached to the weather and sea-exposed plating including any contiguous inboard member within 600 [mm] of the plating	I
Weather-exposed plating and attached framing in cargo holds of ships which by nature of their trade have their cargo hold hatches open during cold weather operations	I
All weather and sea exposed SPECIAL, as defined in Table 2.2.1a) of Pt.3, Ch.2, structural members within 0.2L from FP	II

Table 2.12.1a) : Steel grades for weather exposed plating

Thickness, t [mm]	Material Class I				Material Class II				Material Class III					
	PC1-5		PC6&7		PC1-5		PC6&7		PC1-3		PC4&5		PC6&7	
	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT
$t \le 10$	B	AH	B	AH	B	AH	B	AH	E	EH	E	EH	B	AH
$t \le 15$	B	AH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$15 < t \le 20$	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$20 < t \le 25$	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$25 < t \le 30$	D	DH	B	AH	E	EH 2)	D	DH	E	EH	E	EH	E	EH
$30 < t \le 35$	D	DH	B	AH	E	EH	D	DH	E	EH	E	EH	E	EH
$35 < t \le 40$	D	DH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
$40 < t \le 45$	E	EH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
$45 < t \le 50$	E	EH	D	DH	E	EH	D	DH	F	FH	F	FH	E	EH

Notes to Table 2.12.1a)

1) Includes weather-exposed plating of hull structures and appendages, as well as their outboard framing members, situated above a level of 0.3 [m] below the lowest ice waterline.

2) Grades D, DH are allowed for a single strake of side shell plating not more than 1.8 [m] wide from 0.3 [m] below the lowest ice waterline.

Table 2.12.1b) : Steel grades for inboard framing members attached to weather exposed plating

Thickness t, [mm]	PC1 – PC 5		PC6 and PC7	
	MS	HT	MS	HT
t ≤ 20	B	AH	B	AH
20 < t ≤ 35	D	DH	B	AH
35 < t ≤ 45	D	DH	D	DH
45 < t ≤ 50	E	EH	D	DH

2.12.5 Steel grades for all inboard framing members attached to weather exposed plating are to be not less than given in Table 2.12.1b). This applies to all inboard framing members as well as to other contiguous inboard members (e.g. bulkheads, decks) within 600 [mm] of the exposed plating.

2.12.6 Castings are to have specified properties consistent with the expected service temperature for the cast component.

2.13 Longitudinal strength

2.13.1 Application

2.13.1.1 Ice loads need only be combined with still water loads. The combined stresses are to be compared against permissible bending and shear stresses at different locations along the ship's length. In addition, sufficient local buckling strength is also to be verified.

2.13.2 Design vertical ice force at the bow

2.13.2.1 The design vertical ice force at the bow, F_{IB}, is to be taken as

F_{IB} = minimum ($F_{IB.1}$; $F_{IB.2}$) [MN]

where,

$F_{IB.1} = 0.534 \cdot K_I^{\ 0.15} \cdot \sin^{0.2}(\gamma_{stem}) \cdot (\Delta \cdot K_h)^{0.5} \cdot CF_L$ [MN]

$F_{IB.2} = 1.20 \cdot CF_F$ [MN]

K_I = indentation parameter = K_f / K_h

a) for the case of a blunt bow form

$K_f = (2 \cdot C \cdot B^{1-eb} / (1 + e_b))^{0.9} \cdot \tan(\gamma_{stem})^{-0.9.(1+eb)}$

b) for the case of wedge bow form (α_{stem} < 80 deg), e_b = 1 and the above simplifies to

$K_f = (\tan(\alpha_{stem}) / \tan^2(\gamma_{stem}))^{0.9}$

$K_h = 0.01 \cdot A_{wp}$ [MN/m]

CF_L = longitudinal strength class factor from Table 2.3.2

e_b = bow shape exponent which best describes the waterplane (see Fig.2.13.2.1a) and (Fig.2.13.2.1b)

= 1.0 for a simple wedge bow form
= 0.4 to 0.6 for a spoon bow form
= 0 for a landing craft bow form

An approximate e_b determined by a simple fit is acceptable

γ_{stem} = stem angle to be measured between the horizontal axis and the stem tangent at the upper ice waterline [deg] (buttock angle as per Fig.2.3.2.1 measured on the centerline)

α_{stem} = waterline angle measured in way of the stem at the upper ice waterline (UIWL) [deg] (see Fig. 2.13.2.1a)

$C = 1 / (2 \cdot (L_B / B)^{eb})$

B = ship moulded breadth [m]

L_B = bow length used in the equation $y = B / 2 \cdot (x/L_B)^{eb}$ [m] (see Fig.2.13.2.1a) and Fig.2.13.2.1b)

Δ = ship displacement [k-tonnes], not to be taken less than 10 [k-tonnes]

A_{wp} = ship waterplane area [m^2]

CF_F = flexural failure class factor from Table 2.3.2

Where applicable, draught dependent quantities are to be determined at the waterline corresponding to the loading condition under consideration.

2.13.3 Design vertical ice shear force

2.13.3.1 The design vertical ice shear force, F_I, along the hull girder is to be taken as:

$F_I = C_f \cdot F_{IB}$ [MN]

where,

C_f = longitudinal distribution factor to be taken as follows:

a) Positive shear force

C_f = 0.0 between the aft end of L and 0.6L from aft
C_f = 1.0 between 0.9L from aft and the forward end of L

b) Negative shear force

C_f = 0.0 at the aft end of L
C_f = -0.5 between 0.2 L and 0.6L from aft
C_f = 0.0 between 0.8L from aft and the forward end of L

Intermediate values are to be determined by linear interpolation

2.13.3.2 Shear strength is to be checked as per Pt.3, Ch.5, Sec.4 by substituting the design vertical ice shear force for the design vertical wave shear force. The permissible shear stress τ is to be determined from Table 2.13.5.

2.13.4 Design vertical ice bending moment

2.13.4.1 The design vertical ice bending moment, M_I, along the hull girder is to be taken as:

$M_I = 0.1 \cdot C_m \cdot L \cdot \sin^{-0.2}(\gamma_{stem}) \cdot F_{IB}$ [MNm]

where,

L = rule length [m], but measured on the upper ice waterline (UIWL) [m]
γ_{stem} is as given in 2.13.2.1
F_{IB} = design vertical ice force at the bow [MN]

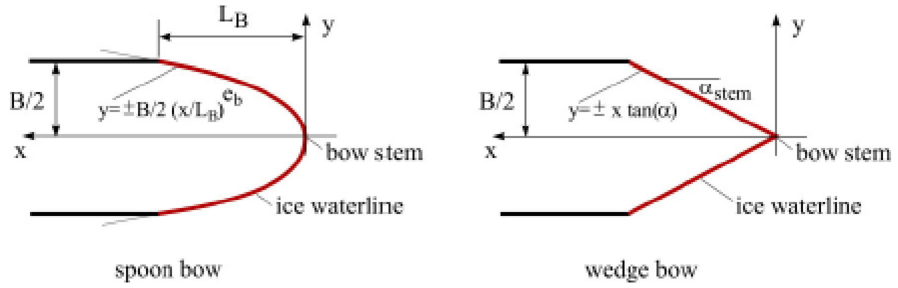


Fig.2.13.2.1a) : Bow shape definition

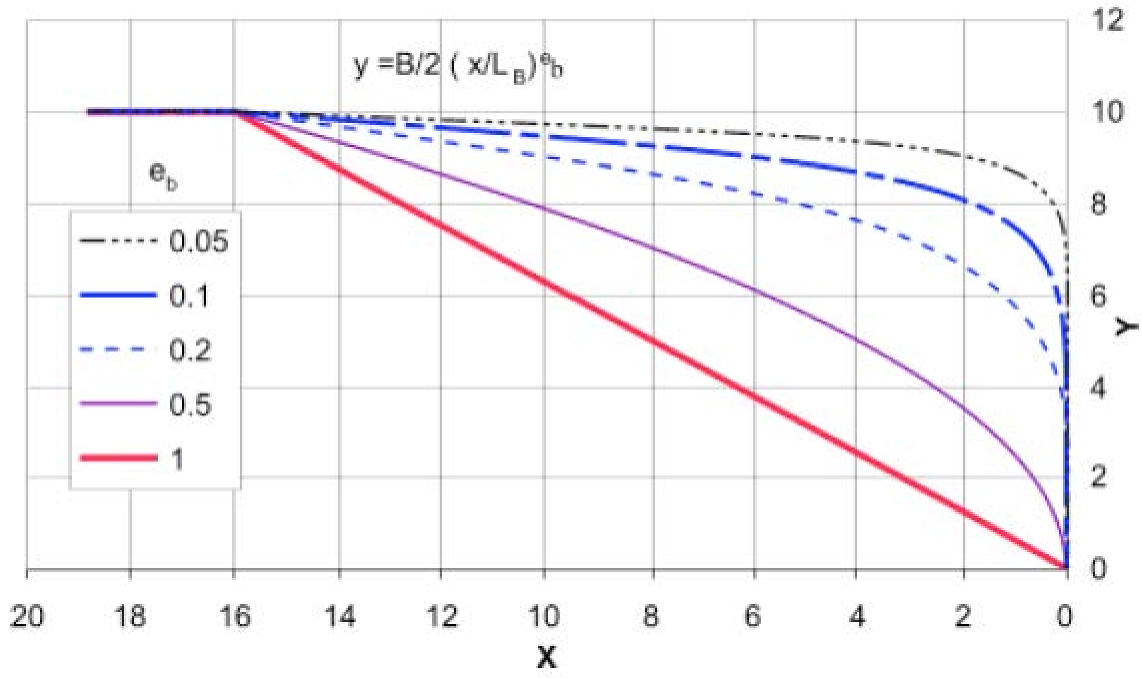


Fig.2.13.2.1b) : Illustration of e_b effect on the bow shape for B = 20 and L_B = 16

C_m = longitudinal distribution factor for design vertical ice bending moment to be taken as follows:

C_m = 0.0 at the aft end of L
C_m = 1.0 between 0.5L and 0.7L from aft
C_m = 0.3 at 0.95L from aft
C_m = 0.0 at the forward end of L

Intermediate values are to be determined by linear interpolation

Where applicable, draught dependent quantities are to be determined at the waterline corresponding to the loading condition under consideration.

2.13.4.2 The required section modulus of the hull girder is to be determined as per Pt.3, Ch.5, 3.3.1 by substituting the design vertical ice bending moment for the design vertical wave bending moment. The ship still water bending moment is to be taken as the maximum sagging moment. The permissible bending stresses is to be determined from Table 2.13.5.

2.13.5 Longitudinal strength criteria

2.13.5.1 The strength criteria provided in Table 2.13.5 are to be satisfied. The design stress is not to exceed the permissible stress.

Table 2.13.5 : Longitudinal strength criteria

Failure Mode	Applied Stress	Permissible stress when $\sigma_y / \sigma_u \le 0.7$	Permissible stress when $\sigma_y / \sigma_u > 0.7$
Tension	σ_a	$\eta \cdot \sigma_y$	$\eta \cdot 0.41 (\sigma_u + \sigma_y)$
Shear	τ_a	$\eta \cdot \sigma_y / \sqrt{3}$	$\eta \cdot 0.41 (\sigma_u + \sigma_y) / \sqrt{3}$
Buckling	σ_a	σ_{cr} for plating and for web plating of stiffeners $\sigma_{cr}/1.1$ for stiffeners	
	τ_a	τ_{cr}	

where,

σ_a = applied vertical bending stress [N/mm^2]

τ_a = applied vertical shear stress [N/mm^2]

σ_y = minimum upper yield stress of the material [N/mm^2]

σ_u = ultimate tensile strength of material [N/mm^2]

σ_{cr} = critical buckling stress in compression, according to Pt.3, Ch.3, Sec.6 [N/mm^2]

τ_{cr} = critical buckling stress in shear, according to Pt.3, Ch.3, Sec.6 [N/mm^2]

η = 0.8.

2.14 Stem and stern frames

2.14.1 When the vessel has a sharp edged stem (see Fig.2.8.1of Pt.5, Ch.21) the thickness of the stem side plate is not to be less than 1.2 times the required plate thickness of the adjacent shell plating.

2.14.2 The plate thickness of a shaped plate stem and in the case of a blunt tow, any part of the shell which forms an angle of 30° or more to the centerline in a longitudinal plane is to be not less than 1.2 times the required thickness of the adjacent shell plating.

2.15 Appendages

2.15.1 All appendages are to be designed to withstand forces appropriate for the location of their attachment to the hull structure or their position within a hull area.

2.16 Local details

2.16.1 The end connections of longitudinal and transverse secondary members, web frames and stringers subjected to all loads are to be supported to transfer the loads to the supporting members. The area of end connections are to be such that shear stress does not exceed σ_y / $\sqrt{3}$ [N/mm^2], where σ_y is the yield stress of the material.

2.16.2 The loads carried by a member in way of cut-outs are not to cause instability. Where necessary, the structure is to be stiffened.

2.17 Direct calculation

2.17.1 Direct calculation are not to be utilized as an alternative to the analytical procedures prescribed in this chapter.

2.17.2 Where direct calculation is used to check the strength of structural systems, the load patch specified in 2.3 is to be applied.

2.18 Welding

2.18.1 All welding within ice-strengthened areas is to be of the double continuous type.

2.18.2 Continuity of strength is to be ensured at all structural connections.

Section 3

Machinery Requirements for Polar Class Ships

3.1 Application

3.1.1 The contents of this section apply to main propulsion, steering gear, emergency and essential auxiliary systems essential for the safety of the ship and the survivability of the crew.

3.2 Documentation and design

3.2.1 Following drawings and particulars are to be submitted.

3.2.1.1 Details of the environmental conditions and the required polar class for the machinery, if different from ship's polar class.

3.2.1.2 Detailed drawings of the main propulsion machinery and description of the main propulsion, steering, emergency and essential auxiliaries. The description is to include operational limitations. Information on essential main propulsion load control functions.

3.2.1.3 Description detailing how main, emergency and auxiliary systems are located and protected to prevent problems from freezing, ice and snow and evidence of their capability to operate in intended environmental conditions.

3.2.1.4 Calculations and documentation indicating compliance with the requirements of this section.

3.2.2 System design

3.2.2.1 Machinery and supporting auxiliary systems are to be designed, constructed and maintained to comply with the requirements of "periodically unmanned machinery spaces" with respect to fire safety. (Refer Pt.5, Ch.22 and Pt.6). Any automation plant (i.e. control, alarm, safety and indication systems) for essential systems installed is to be maintained to the same standard, i.e. the requirement for "periodically unmanned machinery spaces". (Refer Pt.5, Ch.22).

3.2.2.2 Systems, subject to damage by freezing are to be drainable.

3.2.2.3 Single screw vessels classed PC1 to PC5 inclusive are to have means to ensure sufficient vessel operation in the case of propeller damage including CP-mechanism.

3.3 Materials

3.3.1 Materials exposed to sea water

Materials exposed to sea water, such as propeller blades, propeller hub and blade bolts are to have an elongation not less than15% on a test piece the length of which is five times the diameter.

Charpy V impact test is to be carried out for materials other than bronze and austenitic steel. Test pieces taken from the propeller castings are to be representative of the thickest section of the blade. An average impact energy value of 20 J taken from three Charpy V tests is to be obtained at minus 10°C.

3.3.2 Materials exposed to sea water temperature

3.3.2.1 Materials exposed to sea water temperature are to be of steel or other approved ductile material.

3.3.2.2 An average impact energy value of 20 J taken from three tests is to be obtained at minus 10°C.

3.3.3 Material exposed to low air temperature

3.3.3.1 Materials of essential components exposed to low air temperature are to be of steel or other approved ductile material.

3.3.3.2 An average impact energy value of 20 J taken from three Charpy V tests is to be obtained at 10°C below the lowest design temperature.

3.4 Ice interaction load

3.4.1 Propeller ice interaction

3.4.1.1 These Rules cover open and ducted type propellers situated at the stern of a vessel having controllable pitch or fixed pitch blades. Ice loads on bow propellers and pulling type propellers will receive special consideration. The given loads are expected, single occurrence, maximum values for the whole ship's service life for normal operational conditions. These loads do not cover off-design operational conditions, for example when a stopped propeller is dragged through ice. These Rules apply also to azimuthing (geared and podded) thrusters considering loads due to propeller ice interaction. However, ice loads due to ice impacts on the body of azimuthing thrusters are not covered by this section.

3.4.1.2 The loads given in clause 3.4 are total loads (unless otherwise stated) during ice interaction and are to be applied separately (unless otherwise stated) and are intended for component strength calculations only. The different loads given here are to be applied separately.

3.4.1.3 F_b is a force bending a propeller blade backwards when the propeller mills an ice block while rotating ahead. F_f is a force bending a propeller blade forwards when a propeller interacts with an ice block while rotating ahead.

3.4.2 Ice class factors

The Table below lists the design ice thickness and ice strength index to be used for estimation of the propeller ice loads.

Ice Class	**H_{ice} [m]**	**S_{ice} [-]**	**S_{qice} [-]**
PC1	4.0	1.2	1.15
PC2	3.5	1.1	1.15
PC3	3.0	1.1	1.15
PC4	2.5	1.1	1.15
PC5	2.0	1.1	1.15
PC6	1.75	1	1
PC7	1.5	1	1
H_{ice} = Ice thickness for machinery strength design S_{ice} = Ice strength index for blade ice force S_{qice} = Ice strength index for blade ice torque			

3.4.3 Design ice loads for open propeller

3.4.3.1 Maximum backward blade force, F_b

when $D < D_{limit}$,

$$F_b = -27\, S_{ice} [nD]^{0.7} \left[\frac{EAR}{Z}\right]^{0.3} [D]^2 \quad kN$$

when $D \geq D_{limit}$,

$$F_b = -23\, S_{ice} [nD]^{0.7} \left[\frac{EAR}{Z}\right]^{0.3} [H_{ice}]^{1.4} [D] \; kN$$

where $D_{limit} = 0.85 \, . \, (H_{ice})^{1.4}$

n is the nominal rotational speed (at MCR free running condition) [rps] for CP-propeller and 85% of the nominal rotational speed (at MCR free running condition) for FP-propeller (regardless of driving engine type).

F_b is to be applied as a uniform pressure distribution to an area on the back (suction) side of the blade for the following load cases:

d, D, EAR and Z are defined in 3.4.3.2 below.

a) Load Case 1 : from 0.6R to the tip and from the blade leading edge to a value of 0.2 chord length.

b) Load Case 2 : a load equal to 50% of the F_b is to be applied on the propeller tip area outside of 0.9R.

c) Load case 5 : for reversible propellers a load equal to 60% of the F_b is to be applied from 0.6R to the tip and from the blade trailing edge to a value of 0.2 chord length.

See load cases 1, 2 and 5 in Table 1 of Appendix.

3.4.3.2 Maximum forward blade force, F_f

when $D < D_{limit}$

$$F_f = 250 \left[\frac{EAR}{Z}\right] [D]^2 \quad kN$$

when $D \geq D_{limit}$

$$F_f = 500 \left[\frac{1}{1 - \frac{d}{D}}\right] H_{ice} \left[\frac{EAR}{Z}\right] [D] \quad kN$$

where,

$$D_{limit} = \left(\frac{2}{1 - \frac{d}{D}}\right) H_{ice}$$

d = propeller hub diameter [m]

D = propeller diameter [m]
EAR = expanded blade area ratio
Z = number of propeller blades

F_f is to be applied as a uniform pressure distribution to an area on the face (pressure) side of the blade for the following loads cases:

a) Load case 3 : form 0.6R to the tip and from the blade leading edge to a value of 0.2 chord length

b) Load case 4 : a load equal to 50% of the F_f is to be applied on the propeller tip area outside of 0.9R.

c) Load case 5 : for reversible propellers a load equal to 60% F_f is to be applied from 0.6R to the tip and from the blade trailing edge to a value of 0.2 chord length.

See load cases 3, 4 and 5 in Table 1 of Appendix.

3.4.3.3 Maximum blade spindle torque, Q_{smax}

Spindle torques Q_{smax} around the spindle axis of the blade fitting are to be calculated both for the load cases described in 3.4.3.1 and 3.4.3.2 for F_b and F_t. If these spindle torque values are less than the default value given below, the default minimum value is to be used.

Default value : $Q_{smax} = 0.25 \cdot F \cdot C_{0.7}$ [kNm]

where,

$C_{0.7}$ = length of the blade chord at 0.7R radius [m]

F is either F_b or F_f whichever has the greater absolute value.

3.4.3.4 Maximum propeller ice torque applied to the propeller

when $D < D_{limit}$

$Q_{max} = 105 \times (1 - d / D) \times S_{qice} \times (P_{0.7} / D)^{0.16} \times (t_{0.7} / D)^{0.6} \times (nD)^{0.17} \times D^3$ kNm

When $D \geq D_{limit}$

$Q_{max} = 202 \times (1 - d / D) \times S_{qice} \times H_{ice}^{1.1} \times (P_{0.7} / D)^{0.16} \times (t_{0.7} / D)^{0.6} \times (nD)^{0.17} \times D^{1.9}$ kNm

where,

$D_{limit} = 1.81\ H_{ice}$

S_{qice} = ice strength index for blade ice torque

$P_{0.7}$ = propeller pitch at 0.7R [m]

$t_{0.7}$ = max thickness at 0.7 radius [m]

n is the rotational propeller speed, [rps], at bollard condition. If not known, n is to be taken as follows:

Propeller Type	**n**
CP propellers	n_n
FP propellers driven by turbine or electric motor	n_n
FP propellers driven by diesel engine	$0.85\ n_n$

Where n_n is the nominal rotational speed at MCR, free running condition.

For CP propellers, propeller pitch, $P_{0.7}$ is to correspond to MCR in bollard condition. If not known, $P_{0.7}$ is to be taken as $0.7 \cdot P_{0.7n}$, where $P_{0.7n}$ is propeller pitch at MCR free running condition.

3.4.3.5 Maximum propeller ice thrust applied to the shaft

$T_f = 1.1 \cdot F_f$ [kN]

$T_b = 1.1 \cdot F_b$ [kN]

3.4.4 Design ice loads for ducted propeller

3.4.4.1 Maximum backward blade force, F_b

when $D < D_{limit}$

$$F_b = -9.5 S_{ice} \left[\frac{EAR}{Z}\right]^{0.3} [nD]^{0.7}\ D^2$$

when $D \geq D_{limit}$

$$F_b = -66 S_{ice} \left[\frac{EAR}{Z}\right]^{0.3} [nD]^{0.7}\ D^{0.6} [H_{ice}]^{1.4}$$

where $D_{limit} = 4\ H_{ice}$

n is to taken as given in 3.4.3.1

F_b is to be applied as a uniform pressure distribution to an area on the back side for the following load cases (see Table 2 of Appendix):

a) Load case 1 : on the back of the blade from 0.6R to the tip and from the blade leading edge to a value of 0.2 chord length.

b) Load case 5 : for reversible rotation propellers a load equal to 60% of F_b is applied on the blade face from 0.6R to the tip and from the blade trailing edge to a value of 0.2 chord length.

3.4.4.2 Maximum forward blade force, F_f when D $\leq D_{limit}$

$$F_f = 250 \cdot \left[\frac{EAR}{Z}\right] \cdot D^2 \quad [kN]$$

when $D > D_{limit}$

$$F_f = 500 \cdot \left[\frac{EAR}{Z}\right] \cdot D \cdot \frac{1}{\left(1 - \frac{d}{D}\right)} \cdot H_{ice} \quad [kN]$$

$$\text{where } D_{limit} = \frac{2}{\left(1 - \frac{d}{D}\right)} \cdot H_{ice} \quad [m]$$

F_f is to be applied as a uniform pressure distribution to an area on the face (pressure) side for the following load cases (see Table 2 Appendix):

a) Load case 3 : on the blade face from 0.6R to the tip and from the blade leading edge to a value of 0.5 chord length.

b) Load case 5 : a load equal to 60% F_f is to be applied from 0.6R to the tip and from the blade leading edge to a value of 0.2 chord length.

3.4.4.3 Maximum propeller ice torque applied to the propeller

Q_{max} is the maximum torque on a propeller due to ice-propeller interaction.

$$Q_{max} = 74 \cdot \left[1 - \frac{d}{D}\right] \cdot \left[\frac{P_{0.7}}{D}\right]^{0.16} \cdot \left[\frac{t_{0.7}}{D}\right]^{0.6} \cdot (nD)^{0.17} \cdot S_{qice} \cdot D^3 \quad [kNm]$$

when $D \leq D_{limit}$

$$Q_{max} = 141 \cdot \left[1 - \frac{d}{D}\right] \cdot \left[\frac{P_{0.7}}{D}\right]^{0.16} \cdot \left[\frac{t_{0.7}}{D}\right]^{0.6} \cdot (nD)^{0.17} \cdot S_{qice} \cdot D^{1.9} \cdot H_{ice}^{1.1} \quad [kNm]$$

when $D > D_{limit}$

where $D_{limit} = 1.8 \cdot H_{ice}$ [m]

n is the rotational propeller speed [rps] at bollard condition. If not known, n is to be taken as follows:

	n
CP propellers	n_n
FP propellers driven by turbine or electric motor	n_n
FP propellers driven by diesel engine	$0.85\, n_n$

Where n_n is the nominal rotational speed at MCR, free running condition.

For CP propellers, propeller pitch, $P_{0.7}$ is to correspond to MCR in bollard condition. If not known, $P_{0.7}$ is to be taken as $0.7 \cdot P_{0.7n}$, where $P_{0.7n}$ is propeller pitch at MCR free running condition.

3.4.4.4 Maximum blade spindle torque for CP-mechanism design, Q_{smax}

Spindle torque Q_{smax} around the spindle axis of the blade fitting is to be calculated for the load case described in 3.4.1. If these spindle torque values are less than the default value given blow, the default value is to be used.

Default value : $Q_{smax} = 0.25 \cdot F \cdot C_{0.7}$ [kNm]

Where $C_{0.7}$ is the length of the blade section at 0.7R radius and F is either F_b or F_f whichever has the greater absolute value.

3.4.4.5 Maximum propeller ice thrust (applied to the shaft at the location of the propeller)

$T_f = 1.1 \cdot F_f$

$T_b = 1.1 \cdot F_b$

3.4.5 Design loads on propulsion line

3.4.5.1 Torque

The propeller ice torque excitation for shaft line dynamic analysis is to be described by a sequence of blade impacts which are of half sine shape and occur at the blade. The torque due to a single blade ice impact as a function of the propeller rotation angle is then

$Q(\varphi) = C_q \cdot Q_{max} \cdot \sin(\varphi\,(180 / \alpha_i))$ when $\varphi = 0 \ldots \alpha_i$

$Q(\varphi) = 0$ when $\varphi = \alpha_i \ldots 360$

Where C_q and α_i parameters are given in Table 3.4.5.1 :

Table 3.4.5.1			
Torque excitation	**Propeller-ice interaction**	C_q	α_i
Case 1	Single ice block	0.5	45
Case 2	Single ice block	0.75	90
Case 3	Single ice block	1.0	135
Case 4	Two ice blocks with 45 degree phase in rotation angle	0.5	45

The total ice toque is obtained by summing the torques of single blades taking into account the phase shift 360 deg./Z. The number of propeller revolutions during a milling sequence is to be obtained with the formula:

$N_Q = 2 \cdot H_{ice}$

The number of impacts is $Z \cdot N_Q$.

See Fig.1 in Appendix.

Milling torque sequence duration is not valid for pulling bow propellers, which are subject to special consideration.

The response torque at any shaft component is to be analysed considering excitation torque $Q(\varphi)$ at the propeller, actual engine torque Q_e and mass elastic system.

Q_e = actual maximum engine torque at considered speed.

Design torque along propeller shaft line

The design torque (Q_r) of the shaft component is to be determined by means of torsional vibration analysis of the propulsion line. Calculations are to be carried out for all excitation cases given above and the response is to be applied on top of the mean hydrodynamic torque in bollard condition at considered propeller rotational speed.

3.4.5.2 Maximum response thrust (Tr)

Maximum thrust along the propeller shaft line is to be calculated with the formulae below.

The factors 2.2 and 1.5 take into account the dynamic magnification due to axial vibration. Alternatively the propeller thrust magnification factor may be calculated by dynamic analysis.

Maximum shaft thrust forwards :
$T_r = T_n + 2.2 \times T_f$ [kN]

Maximum shaft thrust backwards :

$T_r = 1.5 \times T_b$ [kN]

T_n = propeller bollard thrust [kN]

T_f = maximum forward propeller ice thrust [kN]

If hydrodynamic bollard thrust, T_n is not known, T_n is to be taken as follows:

Propeller type	T_n
CP propellers (open)	1.25 T
CP propellers (ducted)	1.1 T
FP propellers driven by turbine or electric motor	T
FP propellers driven by diesel engine (open)	0.85 T
FP propellers driven by diesel engine (ducted)	0.75 T

T = nominal propeller thrust at MCR at free running open water conditions.

3.4.5.3 Blade failure load for both open and nozzle propeller

The force is acting at 0.8R in the weakest direction of the blade and at a spindle arm of 2/3 of the distance of axis of blade rotation from leading and trailing edge whichever is the greatest.

The blade failure load is:

$$F_{ex} = \frac{0.3 \cdot c \cdot t^2 \cdot \sigma_{ref}}{0.8 \cdot D - 2 \cdot r} 10^3 \quad [kN]$$

where $\sigma_{ref} = 0.6 \cdot \sigma_{0.2} + 0.4 \cdot \sigma_u$ [N/mm^2]

Where σ_{ref} and $\sigma_{0.2}$ are representative values for the blade material.

c, t and r are respectively the actual chord length, thickness and radius in [m] of the cylindrical root section of the blade at the weakest section outside root fillet and typically will be at the termination of the fillet into the blade profile.

3.5 Design

3.5.1 Design principle

The strength of the propulsion line is to be designed

a) for maximum loads given in 3.4;

b) such that the plastic bending of a propeller blade will not cause damages in other propulsion line components;

c) with sufficient fatigue strength.

3.5.2 Azimuthing main propulsors

In addition to the above requirements special consideration is to be given to the loading cases which are extraordinary for propulsion units when compared with conventional propellers. Estimation of the loading cases must reflect the operational realities of the ship and the thrusters. In this respect, for example, the loads caused by impacts of ice blocks on the propeller hub of a pulling propeller must be considered. Also loads due to thrusters operating in an oblique angle to the flow must be considered. The steering mechanism, the fitting of the unit and the body of the thruster are to be designed to withstand the loss of a blade without damage. The plastic bending of a blade is to be considered in the propeller blade position, which causes the maximum load on the component under consideration.

Azimuth thrusters are also to be designed for estimated loads due to thruster body / ice interaction as per 2.15.

3.5.3 Blade design

3.5.3.1 Maximum blade stresses

Blade stresses are to be calculated using the backward and forward loads given in clauses 3.4.3 and 3.4.4. The stresses are to be calculated with recognized and well documented FE analysis or other acceptable alternative method. The stresses on the blade are not to exceed the allowable stresses ${}_{\text{-all}}$ for the blade material given below.

Calculated blade stress for maximum ice load are to comply with the following:

${}_{\text{-calc}} < {}_{\text{-all}} = {}_{\text{-ref}} / S$

S = 1.5

${}_{\text{-ref}}$ = reference stress, defined as:

${}_{\text{-ref}} = 0.7 \cdot \sigma_u$ or

${}_{\text{-ref}} = 0.6 \cdot \sigma_{0.2} + 0.4 \cdot \sigma_u$ whichever is less

where σ_u and $\sigma_{0.2}$ are representative values for the blade material.

3.5.3.2 Blade edge thickness

The blade edge thicknesses t_{ed} and tip thickness t_{tip} are to be greater than t_{edge} given by the following formula:

$$t_{edge} \geq x\, S\, S_{ice} \sqrt{\frac{3 P_{ice}}{\sigma_{ref}}}$$

x = distance from the blade edge measured along the cylindrical sections from the edge and is to be 2.5% of chord length, however not to be taken greater than 45 [mm]. In the tip area (above 0.975R radius) x is to be taken as 2.5% of 0.975R section length and is to be measured perpendicularly to the edge, however not to be taken greater than 45 [mm].

S = safety factor
= 2.5 for trailing edges
= 3.5 for leading edges
= 5 for tip

S_{ice} = according to clause 3.4.2

P_{ice} = ice pressure

= 16 Mpa for leading edge and tip thickness

${}_{\text{-ref}}$ = according to 3.5.3.1

The requirement for edge thickness has to be applied for leading edge and in case of reversible rotation open propellers also for trailing edge. Tip thickness refers to the maximum measured thickness in the tip area above 0.975R radius. The edge thickness in the area between position of maximum tip thickness and edge thickness at 0.975 radius is to be interpolated between edge and tip thickness value and smoothly distributed.

3.5.4 Prime movers

3.5.4.1 The main engine is to be capable of being started and running the propeller with the CP in full pitch.

3.5.4.2 Provisions is to be made for heating arrangements to ensure ready starting of the cold emergency power units at an ambient temperature applicable to the polar class of the ship.

3.5.4.3 Emergency power units are to be equipped with starting devices with a stored energy capability of at least three consecutive starts at the design temperature given in 3.5.4.2 above. The source of stored energy is to be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. A second source of energy is to be provided for an additional three starts within 30 min., unless manual starting can be demonstrated to be effective to Surveyor's satisfaction.

3.6 Machinery fastening loading accelerations

3.6.1 Essential equipment and main propulsion machinery supports are to be suitable for the accelerations as indicated in following clauses. Accelerations are to be considered acting independently.

3.6.2 Longitudinal impact accelerations, a_l

Maximum longitudinal impact acceleration at any point along the hull girder

$$= \left(F_{IB}/\Delta\right)\left\{\left[1.1\tan\left(\gamma+\varphi\right)\right] + \left[7\frac{H}{L}\right]\right\} \ [\mathrm{m/s}]^2$$

3.6.3 Vertical acceleration, a_v

Combined vertical impact acceleration at any point along the hull girder

$= 2.5\ (F_{IB}\ /\ \Delta\ )\ F_x \quad [\mathrm{m/s}]^2$

Fx = 1.3 at FP
= 0.2 at midships
= 0.4 at AP
= 1.3 at AP for vessels conducting ice breaking astern

Intermediate values to be interpolated linearly.

3.6.4 Transverse impact acceleration, a_t

Combined transverse impact acceleration at any point along hull girder

$$= 3F_i \frac{F_x}{\Delta} \quad [\mathrm{m/s}^2]$$

Fx = 1.5 at FP
= 0.25 at midships
= 0.5 at AP
= 1.5 at AP for vessels conducting ice breaking astern

Intermediate values to be interpolated linearly.

where,

ϕ = maximum friction angle between steel and ice, normally taken as 10° [deg.]

γ = bow stem angle at waterline [deg.]

Δ = displacement [k-tonnes]

L = length between perpendiculars [m]

H = distance in meters from the waterline to the point being considered [m]

F_{IB} = vertical impact force, defined in 2.13.2.1

F_i = total force normal to shell plating in the bow area due to oblique ice impact, defined in 2.3.2.1

3.7 Auxiliary systems

3.7.1 Machinery is to be protected from the harmful effects of ingestion or accumulation of ice or snow. Where continuous operation is necessary, means are to be provided to purge the system of accumulated ice or snow.

3.7.2 Means are to be provided to prevent damage due to freezing, to tanks containing liquids.

3.7.3 Vent pipes, intake and discharge pipes and associated systems are to be designed to prevent blockage due to freezing or ice and snow accumulation.

3.8 Sea inlets and cooling water systems

3.8.1 Cooling water systems for machinery that are essential for the propulsion and safety of the vessel, including sea chests inlets, are to be designed for the environmental conditions applicable to the ice class.

3.8.2 At least two sea chests are to be arranged as ice boxes for class PC1 to PC5 inclusive where the calculated volume for each of the ice boxes is to be at least 1 m^3 for every 750 [kW] of the total installed power. For PC6 and PC7 there is to be at least one ice box located preferably near center line.

3.8.3 Ice boxes are to be designed for effective separation of ice and venting of air.

3.8.4 Sea inlet valves are to be secured directly to the ice boxes. The valves are to be of full bore type.

3.8.5 Ice boxes and sea bays are to have vent pipes and are to have shut off valves connected directly to the shell.

3.8.6 Means are to be provided to prevent freezing of sea bays, ice boxes, ship side valves and fittings above the load waterline.

3.8.7 Efficient means are to be provided to re-circulate cooling seawater to the ice box. Total sectional area of the circulating pipes is not to be less than the area of the cooling water discharge pipe.

3.8.8 Detachable gratings or manholes are to be provided for ice boxes. Manholes are to be located above the deepest load line. Access is to be provided to the ice box from above.

3.8.9 Openings in ship sides for ice boxes are to be fitted with gratings or holes or slots in shell plates. The net area through these openings is to be not less than 5 times he area of the inlet pipe. The diameter of holes and width of slot in shell plating is to be not less than 20 [mm]. Gratings of the ice boxes are to be provided with a means of clearing. Clearing pipes are to be provided with screw-down type non-return valves.

3.9 Ballast tanks

3.9.1 Efficient means are to be provided to prevent freezing in fore and after peak tanks and wing tanks located above the water line and where otherwise found necessary.

3.10 Ventilation system

3.10.1 The air intakes for machinery and accommodation ventilation are to be located on both sides of the ship.

3.10.2 Accommodation and ventilation air intakes are to be provided with means of heating.

3.10.3 The temperature of inlet air provided to machinery from the air intakes is to be suitable for the safe operation of the machinery.

3.11 Alternative design

3.11.1 As an alternative – a comprehensive design study may be submitted and validated by an agreed test programme.

APPENDIX

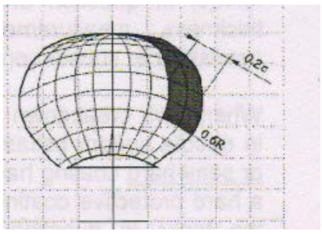
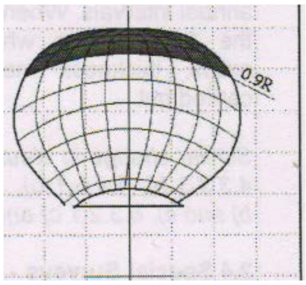
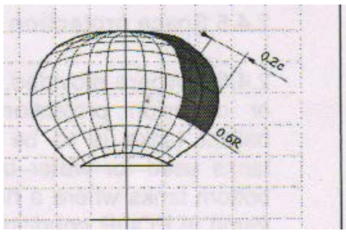
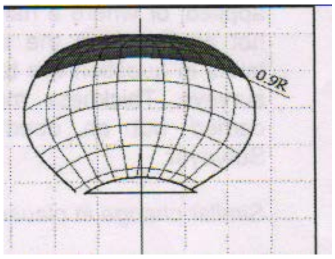
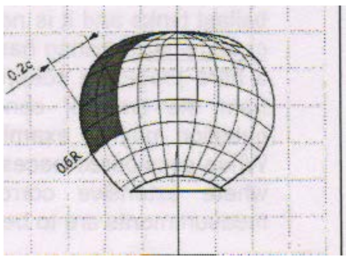
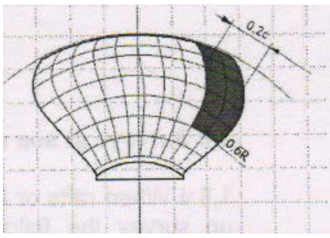
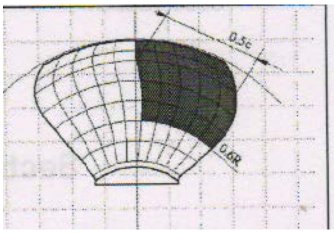
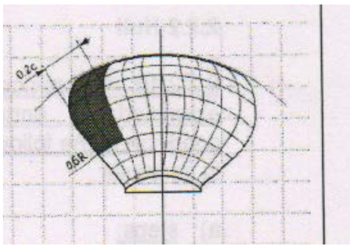
Table 1 : Load cases for open propeller			
	Force	**Loaded area**	**Right handed propeller blade seen from back**
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0.6R to the tip and from the leading edge to 0.2 times the chord length	
Load case 2	50% of F_b	Uniform pressure applied on the back of the blade (suction side) on the propeller tip area outside of 0.9R radius	
Load case 3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0.6R to the tip and from the leading edge to 0.2 times the chord length	
Load case 4	50% of F_f	Uniform pressure applied on propeller face (pressure side) on the propeller tip area outside of 0.9R radius	
Load case 5	60% of F_f or F_b whichever is greater	Uniform pressure applied on propeller face (pressure side) to an area from 0.6R to the tip and from the trailing edge to 0.2 times the chord length	

Table 2 : Load cases for ducted propeller			
	Force	**Loaded area**	**Right handed propeller blade seen from back**
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0.6R to the tip and from the leading edge to 0.2 times the chord length	
Load case 2	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0.6R to the tip and from the leading edge to 0.5 times the chord length	
Load case 3	60% of F_f or F_b whichever is greater	Uniform pressure applied on propeller face (pressure side) to an area from 0.6R to the tip and from the trailing edge to 0.2 times the chord length	

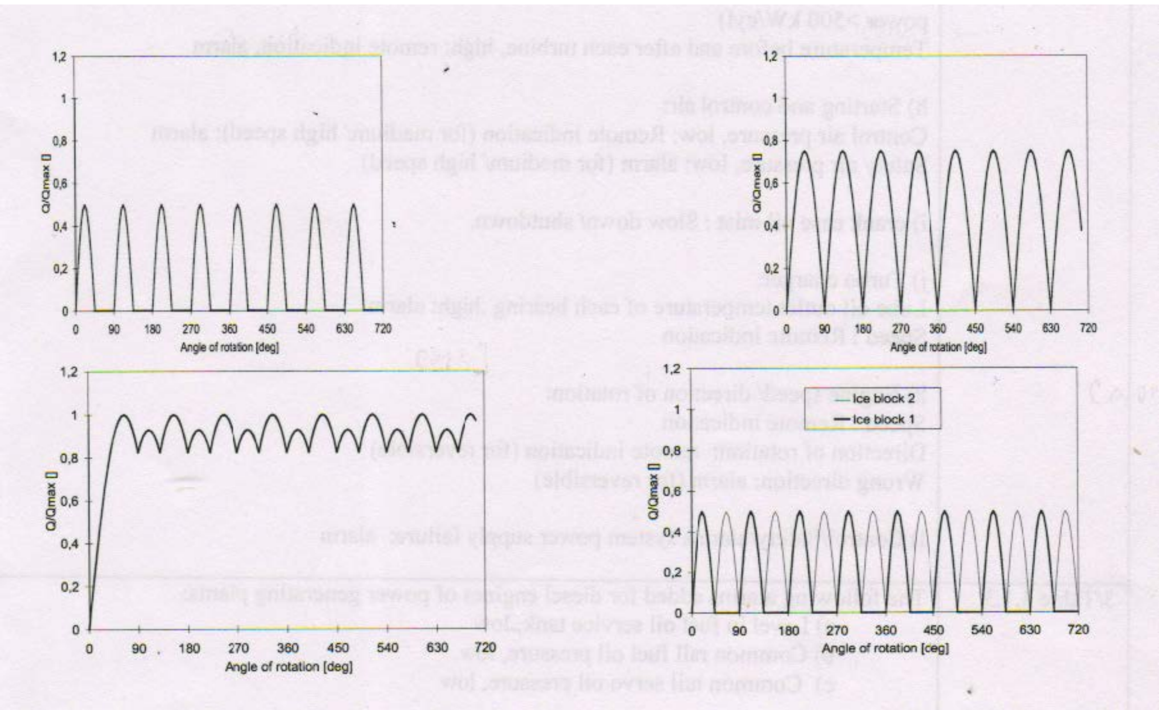


Fig.1 The shape of the propeller ice torque excitation for 45, 90, 135 degrees single blade impact sequences and 45 degrees double blade impact sequence (two ice pieces) on a four bladed propeller

End of Chapter

Chapter 33

Well Stimulation Vessels

Contents

Section

Section 1

General

1.1 Application

1.1.1 The rules in this chapter apply to vessels which are arranged and equipped for stimulation of wells for production of oil and or gas. The requirements are supplementary to those given for assignment of main class.

1.2 Classification and Class Notations

1.2.1 Vessels built and equipped according to the rules in this chapter may be given the additional class notation "**WELL STIMULATION VESSEL"**.

1.2.2 Any additional requirements of the Flag Administration and/or the Coastal State are also to be complied with.

1.3 Definitions

1.3.1 Well Stimulation Systems
Well stimulation is a type of well intervention performed on an oil or gas well to increase production by improving the flow of hydrocarbons from the drainage area into the wellbore. Well stimulation systems are the facilities installed on vessels for the purpose of stimulation of wells to improve their productivity of oil and/or gas. Well stimulation systems may include acidizing equipment, fracturing blenders, pumping units, hydration and chemical additive systems, supporting equipment such as coiled tubing, lifting equipment, well control equipment, pressure vessels, piping, electrical components and control systems.

1.3.2 Lining
Lining is an acid-resistant material that is applied to the tank or piping system in a solid state with a defined elasticity property.

1.4 Scope of Classification

1.4.1 The following matters are covered by classification :

a) Position keeping, intact and damage stability of the vessel.

b) Tanks, pumping and piping arrangement, equipment and instrumentation related to the storage and handling of well stimulation fluids.

c) Personnel protective equipment.

1.5 Plans and Documentation

1.5.1 In addition to plans listed in Part 1, Ch 1, Sec 3, plans/documents given in 1.5.2 to 1.5.6, are to be submitted for information/ approval, as appropriate:

1.5.2 The following drawings are to be submitted for information :

General arrangement plan of well stimulation equipment including hazardous area/zone classification and chemical storage area definition, as well as decontamination and eye-washing facilities, and location of personnel protective equipment.

1.5.3 Arrangement and Equipment Plans.
The following plans/ documentation are to be submitted for approval:

i) Arrangement of all integral and independent tanks, including support and stays of independent tanks

ii) Structural drawings of acid tanks including vent arrangements, information on non-destructive testing of welds, strength and tightness testing, and specification of protective linings

iii) Documentation for liquid nitrogen tanks (plans required for liquefied gas carriers are to be referred Part 5, Ch 4)

iv) Pumping arrangement including diagrams of piping for acid, nitrogen and liquid additives, details of flange connections and pipe clamping/securing as well as specification and data on high pressure flexible hoses with end connections.

v) Mechanical ventilation arrangements of closed and semi-closed spaces containing acid tanks, pipes, pumps, mixers and blenders

vi) Drawings showing location of all electrical equipment in areas containing installations for uninhibited acid

vii) Electrical diagrams of well stimulation systems including single line diagram for intrinsically safe circuits, control and monitoring systems for cargo tank level gauging, overflow protection and emergency shutdown, as well as indication equipment for hydrogen, hydrogen chloride and oxygen

viii) List of explosion protected equipment together with certificates and references to specific diagrams and/or plans

ix) Drawings of pumps and mixers/blenders.

x) Drawings and particulars of nitrogen vaporizer and heat exchangers.

xi) Scope and type of Personnel protective equipment intended to be provided.

1.5.4 The following calculations/ analyses are to be submitted for approval :

i) Stability Calculations.

ii) Calculations demonstrating adequacy of propulsion power required for the vessel to maintain station during well stimulation operations.

iii) Stress analysis of supporting structure in way of flexible hose storage reel(s).

iv) Stress analysis of liquid nitrogen piping and heat exchangers.

v) Stress analysis of high pressure piping.

1.5.5 Documentation for the control and monitoring systems for the following is to be submitted for approval:

i) Cargo tank level measurement system.

ii) Cargo tank overflow protection system.

iii) Emergency shut-down system.

iv) Hydrogen indication equipment.

v) Hydrogen chloride indication equipment.

vi) Oxygen indication equipment.

1.5.6 The values of all design loads for Burner/ Flare Booms, where provided, are to be submitted.

1.6 Operation Manual

1.6.1 Operation manual for well stimulation procedure is to be submitted for approval and the same are to be readily available on board. The manual is to provide instructions and information on safety aspects related to well stimulation processing.

1.6.2 The operation manual is to include details of :

a) protective equipment

b) storage and handling of fluids and dry additives

c) transfer operations

d) emergency shut-down and dis-connection.

Section 2

Position Keeping and Stability

2.1 Position Keeping

2.1.1 It is essential that well stimulation vessels are capable of maintaining their positions safely during well stimulation operations. The means to maintain position may be a mooring system with anchors or dynamic positioning system.

2.1.2 If position mooring is undertaken with anchors, they are to fulfill the requirements for position keeping systems in Ch 10 of the *Rules and Regulations for Construction and Classification of Mobile Offshore Drilling Units*. Precautions are to be taken to prevent damage to seabed equipment and installations by anchors.

2.1.3. Dynamic positioning systems, where used to maintain the vessel's position during well stimulation operations, are to comply with the requirements for the class notation **DP (2)** or **DP (3)**.

2.2 Stability

2.2.1 Intact stability of the vessel should be in accordance with the Guidelines for the Design and Construction of Offshore Supply Vessels 2006 (Res. MSC.235 (82)).

2.2.2 The maximum aggregate quantity of hazardous and noxious liquids normally permitted to be carried is as indicated in the following:

a) 800 [m^3] or
b) a volume in cubic meters equal to 40% of the vessel's deadweight calculated at a cargo density of 1.0,
whichever is the lesser.

2.2.3 The Administration may permit carriage of more than the maximum amount specified above.

2.2.4 Well stimulation vessels which are permitted to carry more than the maximum amount specified in 2.2.2 are to comply with the requirements for intact stability and damage stability requirements in Res. MSC. 235(82) with damage assumption given in 3.2.1 of Res. MSC. 235(82).

Section 3

Well Stimulation Equipment and Systems

3.1 General

3.1.1 The design of well stimulation equipment is to be carried out in accordance with Recognized National/International Standards, acceptable to IRS and the same are to be specified by the designer. The equipment and systems used only for well stimulation operations are in general not subject to classification by IRS, unless requested by the client. Manufacturer's certificate affirming compliance with applicable recognized standards is to be submitted to IRS. Their installations and onboard testing are to be supervised in the aspects of operational safety as to reduce to a minimum any danger to persons on board and marine pollution, due regard to be paid to moving parts, hot surfaces and other hazards. Consequences of failure of systems and equipment essential to the safety of the vessel are to be considered.

3.1.2 Classified areas related to the installation of well stimulation equipment are to be described in accordance with IEC61892-7 and *Rules and Regulations for Construction and Classification of Mobile Offshore Drilling Units, Ch 13.*

3.1.3 The equipment class of vessel chosen for any particular operation should be agreed between the owner of the vessel and the customer based upon a risk analysis of the consequence of loss of position

3.2 Tanks and Piping Arrangement

3.2.1 Tanks for acid(s) and liquefied nitrogen are to be located at a minimum distance of 760 [mm] from the vessel's side and bottom. In sides the distance is to be measured perpendicularly inboard from the vessel's side to the centerline at the level of the summer load line.

3.2.2 Cargoes that react with other cargoes in hazardous manner are to be segregated by means of cofferdam, void space, cargo pump room, empty tank or fuel oil tank. Tanks used for other purposes (except for fresh water and lubricating oils) may be accepted as cofferdams.

3.2.3 For access to all spaces, the minimum spacing between cargo tank boundaries and adjacent ship's structure is to be 600 [mm].

Independent tanks installed in otherwise empty holds or stowed on deck are considered satisfactory in terms of segregation requirements.

3.2.4 The design of tanks and pumping arrangements is to cater for their segregation from machinery spaces, propeller shaft tunnels, dry cargo spaces, accommodation and service spaces, as well as from drinking water and stores for human consumption. The segregation may be achieved by means of cofferdam, void space, cargo pump room, empty tank, oil fuel tank or similar arrangements.

3.2.5 Piping Systems for the well stimulation processing plant are not to pass through any accommodation, service or machinery space other than cargo pump-room or pump-rooms and are to be separated from the machinery and ship piping systems.

3.2.6 Cargo piping is to be joined by welding except as allowed in Part 5, Ch 3, Sec 5.2. Storage tanks, pumps, valves, gaskets and piping for uninhibited acids are to be of corrosion resistant material or to have internal lining of corrosion resistant material. (Also Refer to Section 4, 4.1.3).

3.2.7 Each well injection line is to be provided with a check valve located at a flow-head or a test tree.

3.2.8 Tanks and pumping arrangements for liquid additives having flashpoint below 60°C are to comply with relevant requirements of Part 5 Chapter 3.

Arrangement of pump room for LFL (low flashpoint liquids) substances adjacent to the LFL tanks and without separating cofferdams may be specially considered in each case.

3.2. 9 Requirements for tanks and pumping arrangements for chemicals other than acids will be considered in each case with due regard to the properties of the chemicals and applicable requirements of Part 5, Ch 3, Sec 15.

3.2.10 The well stimulation processing plant is to be remotely controlled from a position outside the area where the well stimulation systems are located.

3.3 Tank Venting

3.3.1 Outlets from safety valves of nitrogen tanks are to be led to open deck. Outlet pipes are to be arranged and supported in order to allow thermal expansion/contraction during release of cold gas. Deck/bulkhead penetrations are to be such that the structures are thermally isolated from the cold pipes.

3.3.2 Vent outlets from acid tanks are to be led to open deck. The outlets are to have a minimum height of 4 m above the deck and located at a minimum horizontal distance of 5 m from openings to accommodation and service spaces.

3.3.3 Vent outlets from acid tanks are to have pressure/vacuum valves and be provided with flame screens.

3.4 Access Openings

3.4.1 Access to enclosed spaces containing tanks, piping, pumps and blenders for uninhibited acid is to be direct from open deck or through air locks from other spaces. The air lock is to have independent mechanical ventilation.

3.4.2 For access through hatches, manholes or horizontal openings, the dimensions are to be sufficient to allow a person wearing a self contained breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of a space.

3.4.3 Minimum clear opening for horizontal access is not to be less than 600 [mm] x 600 [mm] and for vertical openings is not to be less than 600 [mm] x 800 [mm] at a height of not more than 600 [mm] from the bottom shell plating unless gratings or other footholds are provided.

3.5 Ventilation

3.5.1 Ventilation of spaces for acid storage and handling:

i) The spaces containing uninhibited acid are to have independent mechanical ventilation with a capacity of minimum 30 air changes per hour, while those containing inhibited acid a minimum of 20 air changes per hour.

ii) Spaces for acid storage and handling are to be preferably ventilated by local exhaust. Spaces containing acetic acid are to be ventilated by explosion proof electrical equipment.

iii) The discharge suctions are to be located both, at floor and ceiling levels of the space concerned.

3.5.2 Ventilation of other spaces containing equipment for well stimulation:

i) Spaces containing installations for liquid nitrogen are to have a mechanical ventilation system (independent of the ventilation systems for accommodation) with a minimum capacity of 20 air changes per hour.

3.5.3 Ventilation of spaces for additive storage and handling:

i) Ventilation of spaces for storage and handling of dry and liquid additives will be considered in each case depending on the flammability, toxicity and reactivity properties of the additives to be used.

3.6 Spill Protection

3.6.1 A lining of corrosion resistant material extending up to a minimum height of 500 [mm] on the surrounding bulkheads and coaming is to be provided for protection of floors or decks under acid storage tanks, pumps and piping for uninhibited acid. Watertight coaming is to be provided for hatches or other openings in way of such decks with a minimum height of 500 [mm]. The coaming is to be protected by suitable lining or an acid resistant coating. Height requirement for coamings may be waived where this height is not practicable.

3.6.2 In order to keep deck spill away from accommodation and service areas, a permanent coaming of 150 [mm] height is to be provided on deck.

3.6.3 Flanges or other detachable pipe connections are to be covered by spray shields.

3.6.4 Portable shield covers for connecting flanges of loading manifold are to be provided. Drip trays of acid resistant material are to be provided under loading manifold for acid.

3.6.5 Manifolds transferring liquefied gases and other flanged connections in the system are to be provided with drip trays resistant to cryogenic temperatures. The issue of cold cracking of the ship structure, in the event of a liquid nitrogen spill, is to be addressed and mitigation measures provided.

3.7 Drainage

3.7.1 Drainage arrangements for acids are to be of acid resistant materials.

3.7.2 The drainage systems for spaces housing tanks, pumping and piping for acids or additives are to be separate and not to be connected to the drainage system for other areas. These are to be of corrosion resistant materials. These drainage arrangements are to be located within the well stimulation processing area.

3.7.3 Drainage arrangements for void spaces, double bottom tanks and ballast tanks which are not separated from tanks containing well stimulation substances or their residues by a double bulkhead, are to be situated within the processing area.

3.8 Electrical Equipment

3.8.1 Electrical equipment or other ignition sources used in enclosed spaces containing acid tanks and acid pumping arrangements are to be certified as safe for operation in hydrogen/air atmosphere and are to be explosion proof.

3.9 Control and Monitoring Systems

3.9.1 A system of automatic and manual controls together with process shutdown and operating procedures are to be provided. System design is to cater for normal manning during well stimulation operations, accessibility of manual controls and switchover between manual and automatic operations.

3.9.2 Vapour and Gas Detection

i) Vapour detection and alarm systems for hydrogen or hydrogen chloride gas are to be provided in enclosed or semi-enclosed spaces containing installations for uninhibited acid.

ii) Spaces containing tanks and piping for liquid nitrogen are to be equipped with oxygen deficiency monitoring systems.

3.9.3 Gauging and Level Detection

i) Tanks containing liquefied nitrogen are to have gauging and level detection arrangements in accordance with Part 5, Ch 4, Sec.13.

ii) Tanks containing hydrochloric acid are to have a closed gauging system. A high level alarm is to be provided and the alarm is to be activated by a level sensing device, independent of the gauging system.

iii) Spaces containing equipment and storage tanks for the well stimulation system are to be provided with suitable detection and alarm system for liquid leakage.

3.9.4 Emergency Shutdown

i) Emergency stop of all pumps in the oil well stimulation system is to be arranged from one or more positions, outside the area where the system is located.

ii) Liquid nitrogen outlet lines from each nitrogen tank are to be provided with Emergency shut-off valves. These valves are to be remotely controlled from one or more positions outside the area where the oil well stimulation system is located.

iii) Emergency depressurizing and disconnection of the transfer hose are to be arranged from the central control position and from the bridge.

iv) At least one emergency shutdown panel capable of closing all barrier elements of blowout preventer and disconnecting connector for subsea blowout preventer sections is to be provided at a safe and readily accessible location, where applicable.

3.9.5 Electrical power supply is to be from a main power system and from a monitored uninterrupted power supply (UPS). The UPS is to be powered from both the main and emergency power systems and capable of continuously operating for at least 30 minutes upon loss of power from the main source. A reliable power supply is to be provided wherever auxiliary energy is required for functionality of emergency control and shutdown,

3.9.6 Where hydraulic and/or pneumatic power supply is used for actuation of emergency control and shutdown, duplication arrangements are to be made in accordance with the requirements in Part 4, Ch 7 Sec 2. Power supply circuits are to be connected to the main and emergency power sources separately where driving power for hydraulic and/or pneumatic pumps is electric.

3.9.7 A hardwired means for voice communications is to be provided between the central control station for well stimulation operation and the vessel's position keeping control stations.

3.10 Flare / Burner Boom (where provided)

3.10.1 Design Loads

3.10.1.1 The loads to be considered in the design of a boom structure are to include, as applicable:

a) Dead weight of structure, piping, fittings, rigging, snow and ice, walkways, guard rails, etc.

b) Wind loads

c) Thermal and impulsive loads resulting from the use of the flare

d)Vessel motion-induced loads

3.10.1.2 Loads resulting from vessel motions may be estimated as per Pt 3, Ch 4 and wind loads may be established as per *Rules and Regulations for Construction and Classification of Mobile Offshore Drilling Units, Ch 4*.

3.10.1.3 The derivation of loading conditions to be used in the design is to give due account of the operational requirements of the Owner/Operator, and are to reflect both the operational and stowed modes of the boom.

3.10.2 The completed burner assembly is to be pressure-tested from the flexible line connection flange to the burner head. The adequacy of the boom's slewing and topping gear is to be demonstrated by testing after the boom's installation on the drilling unit. The details of the test procedure are to be agreed upon with IRS and witnessed by a Surveyor.

Section 4

Acid and Liquid Nitrogen Systems

4.1 Acid

4.1.1 Materials

4.1.1.1 Part 5 Ch 3, Sec 6 is applicable in general.

4.1.1.2 Storage tanks, pumping and piping for uninhibited acid are to be of corrosion resistant material or are to have internal lining of corrosion resistant material.

4.1.2 Storage Tanks

4.1.2.1 Scantling of integral tanks are to be in accordance with the requirements of Pt 3.

4.1.2.2 Scantlings of independent tanks, constructed mainly of plane surfaces, are to be in accordance with relevant requirements given in Pt.3.Tanks of pressure vessel configuration type (cylinders, spheres etc.) are to be in accordance with the requirements given in Pt 5, Ch.3 Sec.4.

4.1.3 Pumping and Piping

4.1.3.1 The rules in Pt 5, Ch. 3 will apply to pumping and piping systems..

4.1.3.2 The flexible hoses with end connectors are to be in accordance with a recognized standard.

4.2 Liquid Nitrogen

4.2.1 Materials

4.2.1.1 The materials are to be in accordance with the requirements of Pt. 5, Ch.4,Sec. 6.

4.2.2 Storage tank

4.2.2.1 The relevant requirements of Pt. 5, Ch. 4, Sec. 4 are to be applied..

4.2.3 Piping

4.2.3.1 The relevant requirements of Pt. 5, Ch. 4, Sec. 5 are to be applied..

4.2.4 Pressure/temperature control

4.2.4.1 The relevant requirements of Pt. 5, Ch. 4, Sec. 7 are to be applied.

4.2.5 Venting Arrangement

4.2.5.1 The relevant requirements of Pt. 5, Ch. 4, Sec. 8 are to be applied.

4.2.6 Personnel Protection

4.2.6.1 The relevant requirements of Pt. 5, Ch. 4, Sec. 14 are to be applied.

4.2.7 Liquid nitrogen is generally kept at atmospheric pressure within temperature range of -210 [˚C] to -196 [˚C]. Where the working temperature of liquid nitrogen is below -165 [˚C] the selection of structural materials is to be undertaken in consultation with IRS.

4.2.8 Where the working temperature is below -110 [˚C], a complete stress analysis is to be submitted for approval accounting for the weight of pipes, acceleration loads induced by hogging and sagging of the ship, for each branch of the piping system.

Section 5

Personnel and Fire Protection

5.1 Decontamination Showers and Eye Washes

5.1.1 A suitably marked decontamination shower and eyewashes are to be available on deck in a convenient location. The shower and eyewash are to be operable in all ambient conditions. Temperature control of water is to be provided in order to avoid excessive temperature.

5.2 Personnel Protective Equipment

5.2.1 Protective equipment are to be kept onboard in suitable locations as required by Part 5 Chapter 3 for carriage of hydrochloric acid.

5.3 Fire Protection

5.3.1 The arrangement of firefighting stations, fixed fire extinguishing systems and portable fire extinguishers are to be in accordance with Pt 6 and Pt 5, Ch 3, Sec 11.

End of Chapter

Chapter 34

Oil Recovery Vessels

Section | **Contents**

Section 1

General

1.1 Application

1.1.1 This Chapter gives additional requirements for ships which are equipped to recover oil from the sea surface at a safe distance, handle, store and transport the recovered oil.

1.1.2 A ship complying with the applicable requirements of this chapter will be eligible for an appropriate class notation, as given in 1.2, and which will be entered in the Register Book.

1.1.3 Additional requirements may be imposed by the National Administration with whom the ship is registered and/or by the Administration within whose territorial jurisdiction the ship is intended to operate for oil recovery.

1.2 Classification and Class Notations

1.2.1 The Class Notations that may be assigned are as follows:

a) **OIL RECOVERY VESSEL**: A ship designed and constructed primarily for oil recovery duties. The scantlings of recovered oil storage tanks will be specially considered based on the requirements of Pt 5, Ch 2;

b) **OIL RECOVERY**: A ship equipped for carrying out oil recovery in addition to other duties and complying with the applicable requirements of this Chapter;

c) **FP 60C**: A ship designed and equipped to recover polluted water in the event of spills of oils which have, at the time of recovery, a flash point higher than 60 degree Celsius (closed cup test).
The notation is not to be assigned to oil recovery ships carrying recovered oils at a temperature within 15 degree Celsius of its flash point.

1.3 Scope of Classification

1.3.1 The following aspects of vessels related to oil recovery are covered by classification

a) Construction

b) Ship equipment and operation

c) Safety against fire and explosion during handling, storage and transportation of oil recovered from a spill

d) Supporting structures for oil recovery equipment

e) Stability and floatability in all relevant operating conditions

f) Available power for supply to equipment used during oil recovery operations

1.4 Definitions

1.4.1 **Oil Recovery Vessel**: A ship specially equipped with a fixed installation and /or mobile equipment for the removal of oil from the sea surface at a safe distance (see Cl 1.7 also) and its retention on board, carriage and subsequent unloading.

1.4.2 **Recovered Oil**: The top layers of oil polluted water collected by means of skimmers, rotating disk, floating pumps or equivalent systems, with sweeping arms, booms or similar devices.

1.4.3 **Oil recovery Tank**: A tank intended for the retention and transportation of recovered oil.

1.4.4 **Oil Recovery Pump Room**: A space containing the pumps and their accessories for handling of recovered oil.

1.4.5 **Oil Recovery Area**: The oil recovery areas are those parts of the ship which contain the following:

a) oil recovery tanks;
b) oil recovery pump rooms;
c) cofferdams;
d) ballast or void spaces surrounding the integral tanks and hold spaces in which independent tanks are located;
e) deck areas such as :

   i) area above the oil recovery tanks;
   ii) In addition, the deck area extending transversely and longitudinally from the oil recovery tanks over a distance of 3[m], where the rule length of the vessel is 50[m] and over.

1.4.6 **Hazardous Areas**: The areas in which an explosive atmosphere is, or may be, expected to be present in quantities such as to require special precautions for the construction, installation and use of electrical apparatus (See Cl 4.3).

1.4.7 **Gas-safe areas**: The gas areas which are not defined as hazardous.

1.5 Assumptions

1.5.1 The classification of the vessel is based upon the following assumptions:

a) The vessel would carry out oil recovery operations in accordance with the approved operating manual (see Cl 1.7 also);

b) The oil recovery operations would take place in moderate sea conditions

1.6 Submission of Plans

1.6.1 The following plans and/ or information are to be submitted in addition to the supporting documentation required for classification as specified elsewhere in this Chapter :

1.6.1.1 For Approval:

i) Arrangement plan indicating the location of oil recovery and handling equipment including portable ones and tanks utilized for recovered oil;

ii) Structural support in way of oil recovery equipment and loads in way of their foundations;

iii) Structural arrangement of tanks designed for storage of recovered oil including access to those tanks;

iv) Stability calculations for all operating conditions including ballasted condition (See also Cl. 1.9.2);

v) Piping system diagrams for handling recovered oil accompanied by details like size, wall thickness, maximum working pressure and material of all pipes; and the type, size, pressure rating and material of valves and fittings;

vi) Recovered oil tank venting arrangements including position of vent outlets;

vii) Arrangement of openings to hazardous areas and adjacent compartments, self closing doors and their direction of opening;

viii) Ventilation systems for all hazardous areas with details including number of air changes per hour, capacities of fans, air flows, areas subject to positive or negative pressure, location and details of machinery exhaust outlets;

ix) Electrical equipment fitted in hazardous areas, including portable electric equipment connected during oil recovery operations (if any). Other details like model name/ number, manufacturer and certification of explosion proof, intrinsically safe, pressurized equipment are also to be submitted;

x) Wiring diagrams, installation instructions and restrictions imposed by certifying agency for intrinsically safe systems;

xi) Power supply, electrical protection and cabling for oil recovery equipment;

xii) Electrical load schedule considering the use of oil recovery equipment during operations;

xiii) Structural fire protection arrangements, controls and particulars of fixed fire extinguishing systems and portable fire safety equipment;

xiv) Diagrammatic plan of recovered oil heating systems, if installed.

1.6.1.2 For Review/ Information:

i) Specifications of gas detection equipment;

ii) Operating Manual

1.7 Operating Manual

1.7.1 The Operating manual is to be submitted in order to verify that the information included within is consistent with the design information and limitations considered in the vessel's classification.

The following information/ procedures are in general to be included in an operating manual to be available on board:

(a) Guidelines regarding safe distance from an oil spill source including specifying conditions when to withdraw the vessel;

(b) Information regarding the safe use of the ship with respect to, preparing for and conducting oil recovery and subsequent operations;

(c) Establishing and maintaining a safe atmosphere in any space(s) liable to become hazardous during oil recovery and subsequent operations;

(d) Isolation, where necessary, of electrical equipment in zones or spaces considered hazardous during oil recovery and subsequent operations, or on failure of, the measures required to establish and maintain a safe atmosphere;

(e) Gas measurements during operation including hydrogen sulphide gas (on open deck and in spaces where gas might accumulate). Actions to be taken in case of gas detection;

(f) Cleaning and gas freeing of tanks and pipes;

(g) Stability in all the relevant operational conditions;

(h) Firefighting;

(j) Maintenance procedures.

1.8 Testing and Trials

1.8.1 During ship trials, the transfer procedures to oil recovery mode of operation are to be simulated to verify that the vessel will be able to operate, as intended.

1.8.2 Testing of Oil Recovery Equipment: Tests are to be carried out according to an approved trial protocol, in order to check the proper operation of the oil recovery equipment. These tests may be performed during dock and/ or sea trials.

1.9 Intact Stability

1.9.1 Intact stability is to be as per the requirements of Chapters 1, 2 and 3 of Part A of the International Code on Intact Stability, 2008 (Resolution MSC 267(85)), as amended.

1.9.2 The following cases are also to be included in the trim and stability booklet for ships intended to carry out Oil Recovery Operations.

a) Ship in the fully loaded departure condition to the oil recovery spot having all the oil recovery equipment installed on board;

b) Ship in the worst anticipated operating condition during oil recovery operation; the worst operating condition regarding free surface effects when the equipment is fitted in the most unfavorable condition (for example, swiping arm extended).

Section 2

Ship Structure

2.1 General

2.1.1 The vessel is to be provided with:

a) a suitable working deck for use in oil recovery operation;

b) storage tanks for recovered oil;

c) permanently installed pumping and piping arrangement for transfer and discharge of recovered oil.

2.1.2 The visibility from the manoeuvring station is to be such that the Master can easily monitor oil recovery operations both on deck and in the water.

2.1.3 Accommodation areas are to be located as far away as possible from the oil tanks and the deck area, where the recovery operations are performed.

2.1.4 Oil handling areas and equipment on deck are to be provided with a coaming around all pumps, transfer flanges and other connections where leakage may be expected.

2.1.5 The coaming is to have a height of at least 150 [mm]. Each coaming is to be adequately sized to contain deck spills and prevent recovered oil from entering accommodation, machinery, control and service spaces or passing overboard.

2.1.6 Where drains are provided for the coaming, closing devices for these drains are to be permanently attached.

2.1.7 Spill coamings may be of the removable type. Removable coamings are to be constructed of rigid, non oil-absorbent material, leak proof, and may be temporarily fixed to the vessel's structure.

2.1.8 Exhaust outlets from machinery are to be located as high as practicable above the deck and are to be fitted with spark arresters.

2.2 General Arrangement

2.2.1 Tank arrangement

2.2.1.1 Oil recovery tanks are to be separated from machinery spaces of category A, propeller shaft tunnels, dry cargo spaces, accommodations, control stations and service spaces and from drinking water and stores for human consumption by means of a cofferdam or equivalent space.

2.2.1.2 For easy access to all parts, the cofferdams are to have a minimum width of 600 [mm]. Fuel oil tanks, tanks for ballast water, tanks for liquids used for oil treatment, tanks for anti-pollution liquids, storerooms for oil removal equipment and pump-rooms are considered as spaces equivalent to a cofferdam.

2.2.1.3 When this cofferdam is impracticable, oil recovery tanks adjacent to the engine room may be accepted provided that:

a) the boundary bulkheads are accessible for inspection;

b) the boundary bulkheads are connected to adjoining structure by by full penetration welding ;

c) the tanks are pressure tested at each renewal survey.

2.2.1.4 In ships not exclusively used for oil recovery operations, the following may be used as oil recovery tanks:

a) tanks in supply vessels complying with LHNS guidelines;

b) tanks in Well Stimulation Vessels, if designed for a cargo mass density of, at least, 1.025 [t/m^3];

c) water ballast tanks;

d) fuel oil tanks;

e) hoppers spaces;

f) liquid mud tanks.

In all cases, the tanks, their associated equipment and piping are to comply with the requirements for oil recovery tanks.

2.2.1.5 Oil recovery tanks are to be located abaft the collision bulkhead.

2.2.1.6 The coating used in recovered oil tanks is to be of an oil and dispersion resistant type.

2.2.1.7 The height of tanks for recovered oil is not to be less than 1.5 [m].

2.2.1.8 Internal obstructions in tanks for recovered oil are to be provided with adequate openings to allow full flow of oil. The openings are to be so arranged that the tanks can be effectively drained. The area of one single opening is not to be less than twice the sectional area of the discharge pipe.

2.2.2 Accommodation, control station, service and machinery spaces

2.2.2.1 Accommodation or service spaces, control stations or machinery spaces of category A are to be located outside the oil recovery area.

2.2.2.2 Entrances, air inlets and openings to accommodation, service and machinery spaces of category A and control stations are not to face the oil recovery area unless they are spaced at least 7 [m] away from the oil recovery area.

2.2.2.3 Doors to spaces not having access to accommodation, service and machinery spaces and control stations, such as oil recovery control stations, storerooms or equipment rooms, may be permitted within the 7 [m] zone specified above, provided the boundaries of these spaces are insulated to A-60 standard.

2.2.2.4 The requirements of 2.2.2.2 and 2.2.2.3 are not applicable to vessels with class notation **FP 60C**.

2.2.3 Access to spaces in oil recovery area

2.2.3.1 Access hatches (at least 600 mm x 600 mm of clear opening) within the oil recovery area are to be direct from the open deck. Such accesses are to be suitable for cleaning and gas-freeing.

2.2.4 Oil recovery tank construction

2.2.4.1 A cargo density of 1.025 [t/m^3] is to be considered for calculating the internal pressures and forces in cargo tanks according to Pt. 3.

2.2.4.2 All tank openings and connections to the tank are to terminate above the weather deck and are to be located on the top of the tanks.

2.2.4.3 The structural design of the tanks is to take into account the temperature of recovered oil. Additional strength calculations may be required in case of risk of sloshing induced loads. (refer Pt. 3).

2.2.4.4 All tanks exceeding a breadth of 0.56B or a length of 0.1L or 12m whichever is the greater, are normally to be provided with wash bulkheads to reduce sloshing in partially filled tanks.

2.2.5 Supporting structures for oil recovery equipment

2.2.5.1 The supporting structures for oil recovery equipment are to be designed appropriately and submitted to IRS for approval.

2.2.6 Access openings between non hazardous and hazardous spaces (See Cl 4.3 also)

2.2.6.1 Normally, access doors or other openings between non hazardous spaces (such as accommodation, service spaces, machinery spaces, control stations and similar spaces) and hazardous spaces are not permitted.

2.2.6.2 Access (other than access between oil recovery pump room and machinery spaces category A) may be accepted between such spaces and hazardous areas provided that:

.1 The non-hazardous room is to have overpressure ventilation with 20 air changes per hour in relation to the hazardous area.

.2 The doors are to be gastight.

.3 The doors are to be self-closing and preferably arranged to swing into the non-hazardous space so that they are kept closed by the overpressure. Water tight sliding doors are not acceptable.

.4 If a door cannot be made self-closing, a second self-closing door in accordance with 2.2.6.2.2 and 2.2.6.2.3 above is to be arranged (air lock). The doors are to be arranged with sufficient spacing to allow for safe passage.

.5 Self-closing doors may be used for passage, but are not to remain open during oil recovery operations. Signboards are to be fitted to this effect.

.6 Emergency escape hatches to open deck that cannot be made self-closing need not be arranged with an air lock, but they can only be used for emergency escape purpose during oil recovery operations. Signboards are to be fitted to this effect.

Section 3

Pumping, Piping and Ventilation Systems

3.1 Pumping system, piping system and pump-rooms intended for recovered oil

3.1.1 The requirements of Pt 5, Ch 2 Sec 6 to 11 and Pt 4, Ch 2 and 3 are to be complied with, as applicable.

3.1.2 Piping systems for handling recovered oil are not to pass through:

a) accommodation spaces;
b) service spaces;
c) control stations;
d) machinery spaces of category A. (except for vessels with notation **FP 60C**).

3.1.3 Pumping and piping systems intended for recovered oil are to be independent from the other pumping and piping systems of the ship, except in the following cases:

a) Sections of the cargo system of supply vessels (in compliance with LHNS guidelines) or Well Stimulation Vessels used for oil recovery or if fuel oil tanks are used, means are provided to isolate the oil recovery system from any other system from which it may be connected. The connection between the cargo system and the recovered oil transfer piping may consist of movable pipe sections.

b) If water ballast tanks are used as oil recovery tanks when the ship is in oil recovery mode, the water ballast piping is blanked-off at the nearest position at the tank before starting the oil recovery operation. The connection between the oil recovery piping and the water ballast tanks is to be done by means of detachable spool pieces.

3.1.4 Piping intended for recovered oil and located below the main deck may run from the tank it serves and penetrate tank bulkheads or boundaries common to longitudinally or transversely adjacent oil recovery tanks, ballast tanks, empty tanks, pump-rooms or oil recovery pump-rooms, provided that, it is fitted with a stop-valve operable from the weather deck inside the tank, it serves. As an alternative, where an oil recovery tank is adjacent to an oil recovery pump-room, the stop valve operable from the weather deck may be situated on the tank bulkhead on the oil recovery pump-room side, provided an additional valve is fitted between the bulkhead valve and the oil recovery pump. A totally enclosed hydraulically operated valve located outside the oil recovery tank may also be accepted, provided that the valve is:

a) fitted on the bulkhead of the oil recovery tank it serves;
b) suitably protected against mechanical damage;
c) fitted at a distance from the shell as required for damage protection; and
d) operable from the weather deck.

3.1.5 Transfer of recovered oil through hatches by means of flexible hoses or moving piping is not permitted (except for vessels with notation **FP 60C**).

3.2 Oil Recovery Pumps

3.2.1 Oil recovery pumps are to comply with the requirements of cargo pumps for oil tankers; (see Pt. 5, Ch. 2, Sec. 6).

3.2.2 Oil recovery pumps are to be capable of being remotely shutdown from a location which is manned during oil recovery operations and from at least one other location outside the oil recovery area.

3.2.3 If an oil recovery pump serves more than one tank, a stop valve is to be fitted in the line of each tank.

3.2.4 Oil recovery pumps are to be so designed as to minimize the danger of sparking.

3.2.5 For ships not exclusively dedicated to oil recovery operations, the use of portable pumps or pumps serving cargo systems may be permitted, subject to special consideration by the IRS.

3.3 Pump Rooms for Oil Recovery Operations

3.3.1 Pump-rooms containing the pumps for handling the recovered oil are to be provided with a fixed fire-extinguishing system suitable for machinery spaces of category A (except for vessels with notation **FP 60C**).

3.3.2 Means are to be provided to deal with drainage and any possible leakage from oil recovery pumps and valves in the oil recovery pump-room.

3.3.3 Bilge pumping arrangement is to be situated entirely within the oil recovery area. The bilge system is to be operable from outside the oil recovery pump-room.

3.3.4 Oil recovery pumps may also be used for bilge pumping provided they are connected to the oil recovery pump-room bilge piping through a shut-off valve and a non-return valve arranged in series.

3.3.5 For ventilation of oil recovery transfer pump-rooms, see 3.10.

3.4 Vent Pipes in Oil Recovery Tanks

3.4.1 Vent pipes of oil recovery tanks are to lead to the open at least 2.4 [m] above the weather deck.

3.4.2 Vent pipes are to be located at a distance of at least 5 [m] measured horizontally from the nearest air intake or opening to accommodations, control stations, service and machinery spaces of category A and other gas-safe spaces and from ignition sources.

3.4.3 Openings of vent pipes are to be directed to open deck and fitted with:

i) flameproof wire gauze made of corrosion resistant material easily removable for cleaning, and
ii) closing appliances complying with the provisions of Pt 3, Ch 13, Sec 3

3.4.4 For ships, not used exclusively for oil recovery operations, portable vent pipes may be accepted, subject to special consideration by IRS.

3.5 Level Gauging and Overfilling Control of Oil Recovery tanks

3.5.1 Oil recovery tanks are to be fitted with sounding pipes or other level gauging devices of a type approved by IRS.

3.5.2 Oil recovery tanks are to be fitted with a high level alarm or an overflow control system.

3.5.3 The high level alarm is to be of a type approved by the IRS and is to give an audible and visual alarm.

3.6 Heating systems in Oil recovery tanks

3.6.1 Heating systems fitted in oil recovery tanks are to comply with the requirements of Pt 5, Ch. 2, Sec. 10.

3.7 Sea Water Cooling System

3.7.1 One of the suctions serving the sea water cooling system is to be located in the lower part of the hull

3.8 Fire Pumps

3.8.1 Sea suctions serving the fire water pumps are to be located as low as possible.

3.9 Exhaust Systems

3.9.1 Exhaust lines from engines, gas turbines, boilers and incinerators are to be led outside any hazardous area above the deck and are to be fitted with a spark arrester.

3.9.2 Where the distance between the exhaust lines of engines and the hazardous areas is less than 3 [m], the ducts are to be fitted in a position:

i) near the waterline, if cooled by water injection; or

ii) below the waterline, in the other cases.

3.10 Ventilation System

3.10.1 The ventilation systems for hazardous and non-hazardous spaces are to be independent.

3.10.2 Ventilation of oil recovery pump rooms

3.10.2.1 Oil recovery pump rooms are to be provided with a mechanical ventilation system of the extraction type capable of giving at least 20 air changes per hour.

3.10.2.2 Ventilation intakes are to be so arranged as to minimize the possibility of recycling hazardous vapours from ventilation discharge openings.

3.10.2.3 Ventilation exhaust ducts are to discharge upwards to a gas-safe area on the weather deck in locations at least 3 [m] from any ventilation intake and opening to accommodations, service and machinery spaces, control stations and other spaces outside the oil recovery area.

3.10.2.4 Protection screens of not more than 13 [mm] square mesh are to be fitted on ventilation duct intakes and outlets.

3.10.2.5 Ventilation fans are to be of non-sparking construction.

3.10.2.6 The ventilation system is to be capable of being controlled from outside the oil recovery pump-room.

3.10.2.7 Provision is to be made to ventilate such spaces prior to entering the compartment and operating the equipment and a warning notice requiring the use of such ventilation is to be placed outside the compartment.

3.10.2.8 Ventilation ducts are not to lead through accommodations, service and machinery spaces or other similar spaces.

3.10.3 Ventilation of enclosed spaces normally entered during oil recovery operation other than recovery oil pump rooms

3.10.3.1 Enclosed spaces normally entered within the oil recovery area are to be provided with a mechanical ventilation system of the extraction type capable of giving at least 8 air changes per hour.

3.10.3.2 Ventilation intakes are to be located at a distance of not less than 3 [m] from the ventilation outlets of oil recovery pump-rooms.

Section 4

Electrical Installations

4.1 General

4.1.1 Electrical installations are to comply with the relevant requirements of Pt 4, Ch 8, as applicable.

4.2 Supply and Distribution Systems

4.2.1 The following systems of generation and distribution of electrical energy are acceptable:

i) DC Supply:
   a) two-wire insulated

ii) AC Supply:
   a) single-phase, two-wire insulated
   b) three-phase, three-wire insulated.

4.2.2 Earthed systems with hull return are not permitted, with the following exceptions subject to acceptance by IRS. :

i) impressed current cathodic protective systems;

ii) limited and locally earthed systems, such as starting and ignition systems of internal combustion engines, provided that any possible resulting current does not flow directly through any hazardous area;

iii) insulation level monitoring devices, provided that the circulation current of the devices does not exceed 30 [mA] under the most unfavourable conditions.

4.2.3 Earthed systems without hull return are not permitted, except for the following:

i) earthed intrinsically safe circuits and the following other systems subject to acceptance by IRS ;

ii) power supplies, control circuits and instrumentation circuits in non-hazardous areas where technical or safety reasons preclude the use of a system with no connection to earth, provided the current in the hull is limited to not more than 5 A in both normal and fault conditions; or

iii) earthed systems, provided that any possible resulting hull current does not flow directly through any hazardous area; or

iv) isolating transformers or other adequate means, to be provided if the distribution system is extended to areas remote from the machinery space.

4.2.4 No current carrying part is to be earthed in insulated distribution systems, other than the following:

i) through an insulation level monitoring device;
ii) through components used for the suppression of interference in radio circuits.

4.2.5 The devices intended to continuously monitor the insulation level of all distribution systems are also to monitor all circuits, other than intrinsically safe circuits, connected to apparatus in hazardous areas or passing through such areas.

4.2.6 An audible and visual alarm is to be given, at a manned position, in the event of an abnormally low level of insulation.

4.3 Hazardous Zones and Spaces

4.3.1 In order to facilitate the selection of appropriate electrical installations, hazardous areas are classified into zones. The following zones or spaces are regarded as hazardous during and on completion of oil recovery operations, until proven gas-safe:(Refer to 4.3.3 for hazardous zones in vessels with class notation **FP 60C**)

4.3.1.1 Hazardous Areas Zone 0:

i) Interiors of tanks intended for the storage of recovered oil;

ii) Interiors of piping systems intended for the handling of recovered oil including venting arrangement;

iii) Equipment containing recovered oil;

iv) Cofferdams and voids adjacent to recovered oil tanks, containing recovered oil pipe flanges, valves or other sources of release.

4.3.1.2 Hazardous Areas Zone 1:

i) Zones on open deck or semi-enclosed spaces on open deck within 3 [m] of any oil recovery tank outlet, oil recovery manifold valve, oil recovery valve, oil recovery pipe flange and oil recovery hatches;

ii) Oil Recovery Pump Rooms;

iii) Spaces in which oil contaminated equipment for handling the recovered oil is located and oil handling areas;

iv) Enclosed or semi enclosed spaces in which recovered oil pipe flanges, valves or other sources of release are located;

v) Areas on the open deck within a 3 [m] radius of any entrance or ventilation opening to any hazardous area zone 1 space;

vi) Areas on the open deck within a 3 [m] radius of any oil recovery equipment. Equipment includes but is not limited to skimmers, containment booms and reels, and separators;

vii) Areas on open deck within spillage coaming surrounding oil recovery manifold valves and 3 [m] beyond the coaming up to a height of 2.4 [m] above the deck.

4.3.1.3 Hazardous areas zone 2:

i) Enclosed spaces immediately adjacent to recovered oil tanks in any direction, not containing recovered oil pipe flanges, valves, or other sources of release;

ii) Enclosed or semi-enclosed spaces having a direct access or opening to any hazardous area;

iii) Air lock spaces between Zone 1 and non-hazardous space;

iv) Areas on the open deck within 1.5 [m] radius of any entrance or ventilation opening to any hazardous area zone 2 space excluding tanks adjacent to recovered oil tanks not containing recovered oil pipe flanges, valves, or other sources of release.

4.3.2 Hazardous areas are not to contain the following:

i) Internal combustion engines;
ii) Steam turbines and steam piping with a steam temperature in excess of 200 [C];
iii) Other piping system and heat exchangers with surface temperature exceeding 200 [C];
iv) Any other source of ignition.

4.3.3 Hazardous Zones for vessels with class notation **FP 60C**

i) Hazardous Area Zone 2:

a) Interiors of tanks intended for the storage of recovered oil;

b) Interiors of piping systems intended for the handling of recovered oil including venting arrangement;

c) Equipment containing recovered oil;

d) Cofferdams and voids adjacent to recovered oil tanks, containing recovered oil pipe flanges, valves or other sources of release.

4.4 Selection of electrical equipment for installation in hazardous areas

4.4.1 The types of electrical equipment permitted, depending on zones where they are installed are indicated in Pt 4, Ch 8, Sec. 11.

Section 5

Fire Detection, Protection and Fighting

5.1 Vapor Detector

5.1.1 At least one type approved portable gas detection instrument capable of measuring flammable vapour concentrations in air and an equipment for oil flashpoint measurements are to be provided on board.

5.1.2 Alternatively, instead of a portable gas detection instrument, a fixed system may be accepted provided that the sample is drawn from a point within 6 [m] from the waterline.

5.2 Structural Fire protection

5.2.1 Structural Fire Protection requirements as provided in Part 6 are to be complied with, as applicable. In addition, the following special requirements are to be complied with (not applicable for vessels with class notation **FP 60C**) :

5.2.1.1 Unless they are located at least 7 [m] from the nearest oil recovery area, exterior boundaries of the superstructures and deckhouses enclosing accommodation and including any overhanging decks which support such accommodation are to be insulated to A-60 standard for the whole of the portions which face the oil recovery areas up to the underside of the navigation bridge deck and for a distance of 3 [m] aft or forward of such areas.

5.2.1.2 As an alternative to A-60 insulation, a fixed water-spraying system capable of delivering water at a rate of 10 [litre/m^2/min] may be accepted. This system is to comply with the requirements listed in Pt. 5, Ch. 25, Cl. 2.7, except that the only protected area is to be the exterior boundaries of the superstructures and deckhouses enclosing accommodations and including any overhanging decks which support such accommodations facing the oil recovery area. The sea suctions are to be at safe locations sufficiently below the waterline to prevent floating oil from entering the system.

5.2.1.3 Windows and side scuttles fitted within 7 [m] from the nearest oil recovery area are to have the same fire integrity as the bulkhead on which they are fitted. If they have a lower fire rating because they are protected by the fixed water-spraying system mentioned in 5.2.1.2, the windows and side scuttles are to be fitted with inside covers of steel or other equivalent material having a thickness equal to the bulkhead on which they are fitted. Where they are not of the fixed type, they are to be such as to ensure an efficient gastight closure.

5.3 Fire-fighting

5.3.1 Firefighting arrangements are to be provided in accordance with the requirements of Part 6, as applicable. In addition, the following requirements are to be complied with:

.1 For the protection of the oil recovery area, the following fire-fighting equipment is to be provided near the working area:

a) two dry powder fire extinguishers, each with a capacity of at least 50 [kg] or equivalent

b) at least one portable foam extinguishing applicator complying with Pt. 6, Ch. 8, Cl. 4.2.2.

End of Chapter

Rules and Regulations for the Construction and Classification of Steel Ships

Part 6

Fire Safety Requirements

July 2016

IRCLASS
Indian Register of Shipping

Indian Register of Shipping

Part 6

Fire Safety Requirements

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Chapter 1

General

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Section 1

General

1.1 Scope

1.1.1 The requirements of this part generally apply to ships of the following categories to be classed for unrestricted service :

- passenger ships
- cargo ships of 500 gross tons and over.

In case of Special Trade Passenger Vessels, consideration will be given to any exemptions granted by the National Statutory Authorities. (In such cases full compliances with the IMO Rules annexed to the Special Trade Passenger Ships, 1971 and the Protocol on Space Requirements for Special Trade Passenger Ships, 1973; is normally required).

Consideration will also be given to any exemptions granted by the National Statutory Authorities where the sheltered nature and conditions of normal operation are such as to render the application of any specific requirements of this part unreasonable or unnecessary.

Requirements for Cargo Ships below 500 GT will be specially considered, however, as a minimum, these are not to be less than that required by the National Statutory Authorities.

1.1.2 Alternative fire safety design and arrangements which may be proposed in lieu of prescriptive requirements given in Ch.2, 3, 4, 5 or 7 are to comply with the requirements in Ch.6.

1.1.3 Whilst the requirements of this part are considered to meet the Regulations of the International Convention for the Safety of Life at Sea (SOLAS), 1974, and applicable amendments, attention is, however, be given to any relevant requirements of the National Statutory Authority.

1.1.4 Consideration will be given to acceptance of the following as an alternative to the requirements of this part:

a) Requirements of the National Statutory Authority.
b) Fire insulating materials, fire fighting appliances and equipment approved by the National Statutory Authority.

1.1.5 A list of IMO MSC Circulars and Assembly Resolutions referred to in this part is given at the end of this chapter (Table 1).

1.2 Documentation

1.2.1 The plans and particulars detailed in 1.2.2 to 1.2.4 where applicable, are to be submitted for approval, together with all additional relevant information such as gross tonnage and number of passengers, date of build (in case of existing ships), arrangement of helicopter deck etc.

1.2.2 For fire protection, the following plans and information are to be submitted :

a) A statement of the method of structural fire protection adopted indicating compliance with the regulations;

b) A general arrangement plan showing the main fire zones, escape stairways and the structural fire protection bulkheads and decks within the main fire zones, including the engine and boiler rooms, the galleys, paint stores, navigating bridge, radio room, fire fighting control room, emergency generator rooms and battery locker;

c) A plan showing the details of construction of the fire protection bulkheads and decks and the particulars of any surface laminates employed;

d) A plan showing the construction of the fire doors;

e) A ventilation plan showing the ducts and any dampers in them, and the position of the controls for stopping the system;

f) A plan showing the sprinkler system and/or detection system, as applicable;

g) A plan showing the remote control for the fire doors, if applicable;

h) A plan showing the location and arrangement of the emergency stop for the oil fuel unit pumps and for closing the valves on the pipes from oil fuel tanks;

i) A plan of the fire alarm system;

j) Copies of the certificates of approval by National Authorities in respect of all 'A' and 'B' Class fire divisions, non-combustible materials and materials having low flame-spread characteristics, etc., which are to be used but have not been approved by IRS.

1.2.3 For fire extinguishing, the following plans are to be submitted:

a) A general arrangement plan showing the disposition of all the fire fighting equipment including the fire main, the fixed fire extinguishing systems in the cargo holds, on deck and in the machinery spaces; the disposition of the portable and non-portable extinguishers and the types used; and the position and details of the firemen's outfits;

b) A plan showing the layout and construction of the fire main, including the main and emergency fire pumps, isolating valves, pipe sizes and materials; the international shore connections and the cross connections to any other system;

c) A plan showing details of each fixed fire fighting system, including calculations for the quantities of the media used and the proposed rates of application.

1.2.4 For fire control, plans as required by Ch.5, 2.2.4.

1.3 Requirements applicable to existing ships

1.3.1 Unless expressly provided otherwise, for ships constructed before 1 July 2012 the requirements which are applicable under Chapter II-2 of the International Convention for the Safety of Life at Sea, 1974, as amended by resolutions MSC.1(XLV), MSC.6(48), MSC.13(57), MSC.22(59), MSC.24(60), MSC.27(61), MSC.31(63) MSC.57(67), MSC.99(73), MSC.134(76), MSC.194(80), MSC.201(81), MSC.216(82), MSC.256(84), MSC.269(85) and MSC.291(87) are to be complied with.

1.3.2 Ships constructed before 1 July 2002 are also to comply with:

.1 paragraphs 1.5.5 and 1.5.7 as appropriate; (regarding gas freeing of combination carriers and hydro-carbon gas detection systems in tankers);

.2 Ch.4, 2.3.4.2 to 2.3.4.5, 2.4.3 and Ch.5, (except 3.3.2.2 and 3.3.2.3) as appropriate, not later than the date of the first survey after 1 July 2002; (regarding emergency escape breathing devices and operational requirements for fire safety);

.3 Ch.3, 4.4.1.3 and 4.6.4 for new installations only; (regarding prohibition of Halon and safety of deep fat cooking equipment);

.4 Ch.3, 4.5.6 not later than 1 October 2005 for passenger ships of 2,000 gross tonnage and above. (regarding fixed local application fire fighting systems in machinery spaces);

.5 Ch.2, 2.3.1.3.2 (regarding linings, ceilings, partial bulkheads / decks for separating adjacent cabin balconies) and 2.3.4 (regarding furniture and furnishings on cabin balconies) to passenger ships not later than the date of the first survey after 1 July 2008; and

.6 Part 5, Ch 2, 8.2.6 (regarding portable instruments for gas measurement).

1.3.3 Ships constructed on or after 1 July 2002 and before 1 July 2010 are to comply with paragraphs 7.1.1, 7.4.4.2, 7.4.4.3 and 7.5.2.1.2 of SOLAS Regulation II-2/9, as adopted by Resolution MSC.99(73).

(Corresponding clauses 3.7.1.1, 3.7.4.4.2, 3.7.4.4.3 and 3.7.5.2.1.2 of Part 6, Chapter 3 of the previous versions (2002 to 2009) of these rules).

1.3.4 The following ships, with cargo spaces intended for the carriage of packaged dangerous goods, are to comply with Ch.7, Cl.2.3, except when carrying dangerous goods specified as classes 6.2 and 7 and dangerous goods in limited quantities* and excepted quantities** in accordance with Table 2.1 and 2.3 of Ch.7, Section 2, not later than the date of the first renewal survey on or after 1 January 2011:

* Refer to Chapter 3.4 of the IMDG Code.
** Refer to Chapter 3.5 of the IMDG Code.

a) cargo ships of 500 gross tonnage and upwards and passenger ships constructed on or after 1 September 1984 but before 1 January 2011; and

b) cargo ships of less than 500 gross tonnage constructed on or after 1 February 1992 but before 1 January 2011;

and not withstanding the above provisions:

c) cargo ships of 500 gross tonnage and upwards and passenger ships constructed on or after 1 September 1984 but before 1 July 1986 need not comply with Ch.7, Cl.2.3.3 provided that they comply with SOLAS Ch.II-2 regulation 54.2.3 as adopted by resolution MSC.1(XLV) (SOLAS 1981 amendments);

d) cargo ships of 500 gross tonnage and upwards and passenger ships constructed on or after 1 July 1986 but before 1 February 1992 need not comply with Ch.7, Cl.2.3.3 provided that they comply with SOLAS Ch.II-2 regulation 54.2.3 as adopted by resolution MSC.6(48) (SOLAS 1983 amendments);

e) cargo ships of 500 gross tonnage and upwards and passenger ships constructed on or after 1 September 1984 but before 1 July 1998 need not comply with Ch.7, Cl. 2.3.10.1 and Cl. 2.3.10.2; and

f) cargo ships of less than 500 gross tonnage constructed on or after 1 February 1992 but before 1 July 1998 need not comply with Ch.7, Cl.2.3.10.1 and 2.3.10.2.

g) cargo ships of 500 gross tonnage and upwards and passenger ships constructed on or after 1 February 1992 but before 1 July 2002 need not comply with Ch 7, 2.3.3 provided that they comply with SOLAS Ch.II-2 regulation 54.2.3 as adopted by resolution MSC.13(57)

h) cargo ships of 500 gross tonnage and upwards and passenger ships constructed on or after 1 September 1984 but before 1 July 2002 need not comply with Ch 7, 2.3.1, 2.3.5, 2.3.6, 2.3.9, provided that they comply with SOLAS Ch.II-2 regulations 54.2.1, 54.2.5, 54.2.6, 54.2.9 as adopted by resolution MSC.1(XLV).

1.3.5 Ships constructed before 01 July 2012 are to also comply with requirements of Chapter 3, 4.10.1.2.

1.3.6 Vehicle carriers constructed before 1 January 2016, including those constructed before 1 July 2012, are to comply with Pt 6, Ch 7, 4.2.2.

1.3.7 Tankers constructed before 1 January 2016, including those constructed before 1 July 2012, are to comply with Pt 6, Ch 5, 3.3.3 except 3.3.3.3.

1.3.8 Pt 6, Ch 2, 1.5.5.1.1 and 1.5.5.1.3 apply to ships constructed on or after 1 January 2002 but before 1 January 2016, and regulation 1.5.5.2.1 applies to all ships constructed before 1 January 2016

1.4 Applicable requirements depending on ship type

Unless expressly provided otherwise:

.1 requirements not referring to a specific ship type apply to ships of all types; and

.2 requirements referring to "tankers" apply to tankers (see 3.48 for definition), however these are also subject to the requirements specified in paragraph 1.5 below.

1.5 Application of requirements for tankers

1.5.1 Requirements for tankers in this part are to apply to tankers carrying

a) crude oil or

b) petroleum products having a flashpoint not exceeding 60°C (closed cup test), as determined by an approved flashpoint apparatus and a Reid vapour pressure which is below the atmospheric pressure or

c) other liquid products having a similar fire hazard.

(Also see 3.48 for definition of 'tanker').

1.5.2 Where liquid cargoes other than those referred to in paragraph 1.5.1 or liquefied gases which introduce additional fire hazards are intended to be carried, additional safety measures are to be provided in accordance with the requirements of Pt.5, Ch.3 and Ch.4.

1.5.2.1 A liquid cargo with a flashpoint of not exceeding 60°C for which a regular foam firefighting system complying with the Fire Safety Systems Code is not effective, is considered to be a cargo introducing additional fire hazards in this context. The following additional measures are required:

.1 the foam is to be of alcohol resistant type;

.2 the type of foam concentrates for use in chemical tankers is to be approved by the National Statutory Authority (Refer to the Guidelines for performance and testing criteria and surveys of expansion foam concentrates for fire extinguishing systems for chemical tankers (MSC/Circ.799)); and

.3 the capacity and application rates of the foam extinguishing system is to comply with Pt.5, Ch.3, Sec.11, except that lower application rates may be accepted based on performance tests. For tankers fitted with inert gas systems, a quantity of foam concentrate sufficient for 20 min of foam generation may be accepted. (Refer to the Information on flashpoint and recommended fire-fighting media for chemicals to which neither the IBC nor BCH Codes apply (MSC/Circ. 553)).

1.5.2.2 For the purpose of this Section a liquid cargo with a vapour pressure greater than 1.013 bar absolute at 37.8°C is considered to be a cargo introducing additional fire hazards and ships carrying such substances are to comply with paragraph 15.14 of Pt.5, Ch.3. When such ships operate in restricted areas and at restricted times, the requirements for refrigeration systems may be waived in accordance with paragraph 15.14.3 of Pt.5, Ch.3.

1.5.3 Liquid cargoes with a flashpoint exceeding 60°C, other than oil products or liquid cargoes subject to the requirements of Pt.5, Ch.3, are considered to constitute a low fire risk, not requiring the protection of a fixed foam extinguishing system.

1.5.4 Tankers carrying petroleum products with a flashpoint exceeding 60°C are to comply with the requirements provided in Ch.3, 4.2.1.4.4 and 4.10.2.3 and the requirements for cargo ships other than tankers, except that, in lieu of the fixed fire extinguishing system required in Ch.3, 4.7 they are to be fitted with a fixed deck foam system which is to comply with the provisions of the Fire Safety Systems Code.

1.5.5 Combination carriers are not to carry cargoes other than oil unless all cargo tanks are empty of oil and gas freed or unless the arrangements in each case are approved in accordance with the Guidelines for inert gas systems (MSC/Circ.353), as amended by (MSC/Circ.387).

1.5.6 Chemical tankers and gas carriers are to comply with the requirements for tankers, except where alternative and supplementary arrangements are provided in accordance with Pt.5, Ch.3 and Ch.4 as appropriate.

1.5.7 The requirements of Pt.5, Ch.2, 6.4.2 and 6.4.5 and a system for continuous monitoring of the concentration of hydrocarbon gases are to be fitted on all tankers constructed before 1 July 2002 by the date of the first scheduled dry-docking after 1 July 2002, but not later than 1 July 2005. Sampling points or detector heads are to be located in suitable positions in order that potentially dangerous leakages are to readily detected. When the hydrocarbon gas concentration reaches a pre-set level which is not to be higher than 10% of the lower flammable limit, a continuous audible and visual alarm signal is to be automatically effected in the pump-room and cargo control room to alert personnel to the potential hazard. However, existing monitoring systems already fitted having a pre-set level not greater than 30% of the lower flammable limit may be accepted.

Section 2

Fire Safety Objectives and Functional Requirements

2.1 Fire safety objectives

2.1.1 The fire safety objectives of this part are to:

.1 prevent the occurrence of fire and explosion;
.2 reduce the risk to life caused by fire;
.3 reduce the risk of damage caused by fire to the ship, its cargo and the environment;
.4 contain, control and suppress fire and explosion in the compartment of origin; and
.5 provide adequate and readily accessible means of escape for passengers and crew.

2.2 Functional requirements

2.2.1 In order to achieve the fire safety objectives set out in paragraph 2.1 above, the following functional requirements are embodied in the regulations of this chapter as appropriate:

.1 division of the ship into main vertical and horizontal zones by thermal and structural boundaries;

.2 separation of accommodation spaces from the remainder of the ship by thermal and structural boundaries;

.3 restricted use of combustible materials;

.4 detection of any fire in the zone of origin;

.5 containment and extinction of any fire in the space of origin;

.6 identification and protection of means of escape;

.7 access for fire-fighting;

.8 ready availability of fire-extinguishing appliances; and

.9 minimization of possibility of ignition of flammable cargo vapour.

2.3 Achievement of the fire safety objectives

2.3.1 The fire safety objectives set out in paragraph 2.1 above are to be achieved by ensuring compliance with the prescriptive requirements specified in chapters 2, 3, 4, 5 and 7, or by alternative design and arrangements which comply with chapter 6. A ship will be considered to meet the functional requirements set out in paragraph 2.2 and to achieve the fire safety objectives set out in paragraph 2.1 when either:

.1 the ship's designs and arrangements, as a whole complies with the relevant prescriptive requirements in chapters, 2, 3, 4, 5 and 7;

.2 the ship's designs and arrangements, as a whole, have been reviewed and approved in accordance with chapter 6;

.3 part(s) of the ship's design and arrangements have been reviewed and approved in accordance with chapter 6 and the remaining parts of the ship comply with the relevant prescriptive requirements in chapters 2, 3, 4, 5 and 7.

Section 3

Definitions

3. For the purpose of this chapter, unless expressly provided otherwise, the following definitions are to apply:

3.1 **Accommodation spaces** are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces.

3.2 **'A' class divisions** are those divisions formed by bulkheads and decks which comply with the following criteria:

1. they are constructed of steel or other equivalent material;

2. they are suitably stiffened;

3. they are so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test;

4. they are insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180°C above the original temperature within the time listed below:

Class 'A-60'	60 minutes
Class 'A-30'	30 minutes
Class 'A-15'	15 minutes
Class 'A-0'	0 minutes

IR4. Insulated “A” class bulkheads and decks used on board ships, including the means of affixing the insulation to the "A” class structural members, are to be consistent with the materials, details and arrangements used during the tests and documented in the test reports issued for the approval for that insulating material.

5. a test of prototype bulkhead or deck will be required to ensure that it meets the above requirements for integrity and temperature rise.

3.3 **Atriums** are public spaces within a single main vertical zone spanning three or more open decks.

3.4 **'B' class divisions** are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following criteria:

a) they are so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test;

b) they have an insulation value such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature nor will the temperature at any point, including any joint, rise more than 225°C above the original temperature, within the time listed below:

Class 'B-15'	15 minutes
Class 'B-0'	0 minutes

c) they are constructed of approved non-combustible materials and all materials entering into the construction and erection of 'B' class divisions are to be non-combustible. A division consisting of a non-combustible core and combustible veneers may be accepted as a B class division, provided that the non combustible core and veneers are tested in accordance with relevant parts of Fire Test Procedure Code described in 3.23 of this section;

d) a test of a prototype division will be required to ensure that it meets the above requirements for integrity and temperature rise.

3.5 **Bulkhead deck** is the uppermost deck upto which the transverse watertight bulkheads are carried.

3.6 **Cargo area** is that part of the ship that contains cargo holds, cargo tanks, slop tanks and cargo pump-rooms including pump-rooms, cofferdams, ballast and void spaces adjacent to cargo tanks and slop tanks and also deck areas throughout the length and breadth of the part of the ship over the above mentioned spaces. (Also see Ch.2, IR1.5.1.1.2).

3.7 **A cargo ship** is any ship which is not a passenger ship.

3.8 **Cargo spaces** are spaces used for cargo, cargo oil tanks, tanks for other liquid cargo and trunks to such spaces.

3.9 **Central Control station** is a control station in which the following control and indicator functions are centralized:

a) fixed fire detection and alarm systems;

b) automatic sprinklers, fire detection and alarm systems;

c) fire door indicator panels;

d) fire door closures;

e) watertight door indicator panels;

f) watertight door closures;

g) ventilation fans;

h) general/fire alarms;

i) communication systems including telephones; and

j) microphones to public address system.

3.10 **'C' class divisions** are divisions constructed of approved non- combustible materials. They need meet neither requirements relative to the passage of smoke and flame nor limitations relative to the temperature rise. A division consisting of a non-combustible core and combustible veneers may be accepted as a C class division, provided that the non-combustible core and veneers are tested in accordance with relevant parts of Fire Test Procedure Code.

3.11 **Chemical tanker** is a cargo ship constructed or adapted and used for the carriage in bulk of any liquid product of a flammable nature listed in Pt.5, Ch.3 of the Rules.

3.12 **Closed ro/ro spaces** are Ro/Ro spaces which are neither open Ro/Ro spaces nor weather decks.

3.13 **Closed vehicle spaces** are vehicle spaces which are neither open vehicle spaces or weather decks.

3.14 **A combination carrier** is a cargo ship designed to carry both oil and solid cargoes in bulk.

3.15 C**ombustible material** is any material other than a non-combustible material.

3.16 **Continuous 'B' class ceilings or linings** are those 'B' class ceilings or linings which terminate only at an 'A' or 'B' class division.

3.17 **Continuously manned central control station** is a central control station which is continuously manned by a responsible member of the crew.

3.18 **Control-stations** are those spaces in which the ship's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralized. Spaces where the fire recording or fire control equipment is centralized are also considered to be a **Fire Control Station**.
If the CO_2 system discharge pipes are used for the sample extraction smoke detection system, the control panel can be located in the CO_2 room provided that an indicating unit is located on the navigation bridge. Such arrangements are considered to satisfy the requirements of Pt.6 Ch 8, 10.2.4.1.2.

Notes :

1) Indicating unit has the same meaning as repeater panel and observation of smoke should be made either by electrical means or by visual on repeater panel.

2) Main navigational equipment includes, in particular, the steering stand and the compass, radar and direction-finding equipment.

3) Steering gear rooms containing an emergency steering position are not considered to be control stations.

4) Where, in the Rules in Pt.6, relevant to fixed fire extinguishing systems, there are no specific requirements for the centralization within a control station of major components of the system, such major components may be placed in spaces which are not considered to be a control station.

5) Spaces containing, for instance, the following battery sources are to be regarded as control stations regardless of battery capacity:

   .1 emergency batteries in separate battery room for power supply from black-out till start of emergency generator.

.2 emergency batteries in separate battery room as reserve source of energy to radiotelegraph installation.

.3 batteries for start of emergency generator and

.4 in general, all emergency batteries required in accordance with Pt.4, Ch.8, 2.8.

3.19 **Crude oil** is any oil occurring naturally in the earth whether or not treated to render it suitable for transportation and includes :

a) crude oil from which certain distillate fractions may have been removed; and

b) crude oil to which certain distillate fractions may have been added.

3.20 **Dangerous goods** are those goods referred to in SOLAS Regulation VII/2.

3.21 **Deadweight** is the difference in tonnes between the displacement of a ship in water of a specific gravity of 1.025 at the load water-line corresponding to the assigned summer freeboard and the lightweight of the ship.

3.22 **Fire safety systems code** means the International Code for Fire Safety Systems as adopted by the Maritime Safety Committee of the IMO by resolution MSC.98(73) and as may be amended by IMO (Section 21 to 35). Refer Ch.8.

3.23 **Fire test procedures code** means the International Code for Application of Fire Test Procedures, 2010 (2010 FTP Code) as adopted by the Maritime Safety Committee of IMO by resolution MSC.307(88), and as may be amended by IMO.

3.24 **Flashpoint** is the temperature in degrees Celsius (closed cup test) at which a product will give off enough flammable vapour to be ignited, as determined by an approved flashpoint apparatus.

3.25 **Gas carrier** is a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas or other products of a flammable nature listed in Pt.5, Ch.4.

3.26 **Helideck** is a purpose-built helicopter landing area located on a ship including all structure, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

3.27 **Helicopter facility** is a helideck including any refuelling and hangar facilities.

3.28 **Lightweight** is the displacement of a ship in tonnes without cargo, fuel, lubricating oil, ballast water, fresh water and feed water in tanks, consumable stores, and passengers and crew and their effects.

3.29 **Low flame spread** means that the surface thus described will adequately restrict the spread of flame, this being determined in accordance with Fire Test Procedures Code.

3.30 **Machinery spaces** are all machinery spaces of category 'A' and all other spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

3.31 **Machinery spaces of category 'A'** are those spaces and trunks to such spaces which contain:

a) internal combustion machinery used for main propulsion; or

b) internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 [kW]; or

c) any oil-fired boiler or oil fuel unit, or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

3.32 **Main vertical zones** are those sections into which the hull, superstructure, and deckhouses are divided by 'A' class divisions, the mean length of which on any deck does not in general exceed 40 [m].

3.33 **Non-combustible material** is a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the Fire Test Procedures Code.

3.34 **Oil fuel unit** is the equipment used for the preparation of oil fuel heated or not, for delivery to an oil fired boiler (including inert gas generators, incinerator, waste disposal unit, etc.) or to an internal combustion engine (including gas turbines) and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0.18 [N/mm^2]. Oil fuel transfer pumps are not considered as oil fuel units.

3.35 **Open ro/ro spaces** are those ro/ro spaces that are either open at both ends or have an opening at one end and are provided with adequate natural ventilation effective over their entire length through permanent openings distributed in the side plating or deckhead or from above, having a total area of at least 10% of the total area of the spaces sides.

3.36 **Open vehicle spaces** are those vehicle spaces either open at both ends, or have an opening at one end and are provided with adequate natural ventilation effective over their entire length through permanent openings distributed in the side plating or deckhead or from above, having a total area of at least 10% of the total area of the space sides.

3.37 **A passenger ship** is a ship which carries more than twelve passengers, a passenger being every person other than :

- the master and members of the crew or other persons employed or engaged in any capacity on board a ship on the business of the ship; and

- a child under one year of age.

3.38 **Prescriptive requirements** means the construction characteristics, limiting dimensions or fire safety systems specified in chapters, 2, 3, 4, 5 or 7.

3.39 **Public spaces** are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

3.40 **Rooms containing furniture and furnishings of restricted fire risk** are those rooms containing furniture and furnishing of restricted fire risk (whether cabins, public spaces, offices or other types of accommodation) in which :

a) case furniture such as desks, wardrobes, dressing tables, bureaux, dressers, are constructed entirely of approved non-combustible materials, except that a combustible veneer not exceeding 2 [mm] may be used on the working surface of such articles;

b) free-standing furniture such as chairs, sofas, tables, is constructed with frames of non-combustible materials;

c) draperies, curtains and other suspended textile materials have qualities of resistance to the propagation of flame not inferior to those of wool of mass 0.8 [kg/m^2], this being determined in accordance with the Fire Test Procedures Code;

d) floor coverings have low flame spread characteristics;

e) exposed surfaces of bulkheads, linings and ceilings have low flame- spread characteristics;

f) upholstered furniture has qualities of resistance to the ignition and propagation of flame, this being determined in accordance with the Fire Test Procedures Code; and

g) bedding components have qualities of resistance to the ignition and propagation of flame, this being determined in accordance with the Fire Test Procedures Code.

3.41 **Ro/ro spaces** are spaces not normally subdivided in any way and normally extending to either a substantial length or the entire length of the ship in which motor vehicles with fuel in their tanks for their own propulsion and/or goods (packaged or in bulk, in or on rail or road cars, vehicles (including road or rail tankers), trailers, containers, pallets, demountable tanks or in or on similar stowage units or other receptacles) can be loaded and unloaded normally in horizontal direction.

3.42 **A Ro-ro passenger ship** means a passenger ship with ro-ro cargo spaces or special category spaces.

3.43 **Steel or other equivalent material**. Where the words **steel or other equivalent material** occur, 'equivalent material' means any non-combustible material which, by itself or due to insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable fire exposure to the standard fire test (e.g. aluminium alloy with appropriate insulation).

3.44 **Sauna** is a hot room with temperatures normally varying between 80°C - 120°C where the heat is provided by a hot surface (e.g. by an electrically-heated oven). The hot room may also include the space where the oven is located and adjacent bathrooms.

3.45 **Service spaces** are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store rooms, workshops other than those forming part of machinery spaces, and similar spaces and trunks to such spaces.

3.46 **Special category spaces** are those enclosed vehicle spaces above and below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access. Special category spaces may be accommodated on more than one deck provided that the total overall clear height for vehicles does not exceed 10 [m].

3.47 **A standard fire test** is one in which specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time temperature curve. The test method is to be in accordance with the Fire Test Procedures Code.

3.48 **A tanker** is a cargo ship constructed or adapted for the carriage in bulk of liquid cargoes of a flammable nature.

3.49 **Vehicle spaces** are cargo spaces intended for carriage of motor vehicles with fuel in their tanks for their own propulsion.

3.50 **Weather deck** is a deck which is completely exposed to the weather from above and from at least two sides.

3.51 **Cabin balcony** is an open deck space which is provided for the exclusive use of the occupants of a single cabin and has direct access from such a cabin.

3.52 **Safe area** in the context of a casualty and from the perspective of habitability is any area(s) which is not flooded or which is outside the main vertical zone(s) in which a fire has occurred such that it can safely accommodate all persons onboard to protect them from hazards to life or health and provide them with basic services.

3.53 **Safety centre** is a control station dedicated to the management of emergency situations. Safety systems' operation, control and/or monitoring are an integral part of the safety centre.

3.54 **Fire damper** is, for the purpose of implementing Pt 6, Ch 3, 3.7, a device installed in a ventilation duct, which under normal conditions remains open allowing flow in the duct, and is closed during a fire, preventing the flow in the duct to restrict the passage of fire. In using the above definition the following terms may be associated:

.1 automatic fire damper is a fire damper that closes independently in response to exposure to fire products;

.2 manual fire damper is a fire damper that is intended to be opened or closed by the crew by hand at the damper itself; and

.3 remotely operated fire damper is a fire damper that is closed by the crew through a control located at a distance away from the controlled damper.

3.55 **Smoke damper** is, for the purpose of implementing Pt 6, Ch 3, 3.7, a device installed in a ventilation duct, which under normal conditions remains open allowing flow in the duct, and is closed during a fire, preventing the flow in the duct to restrict the passage of smoke and hot gases. A smoke damper is not expected to contribute to the integrity of a fire rated division penetrated by a ventilation duct. In using the above definition the following terms may be associated:

.1 automatic smoke damper is a smoke damper that closes independently in response to exposure to smoke or hot gases;

.2 manual smoke damper is a smoke damper intended to be opened or closed by the crew by hand at the damper itself; and

.3 remotely operated smoke damper is a smoke damper that is closed by the crew through a control located at a distance away from the controlled damper.

3.56 **Vehicle carrier** means a cargo ship with multi deck ro-ro spaces designed for the carriage of empty cars and trucks as cargo.

Table 1 : List of IMO MSC Circulars and Assembly Resolutions referred to in this part

MSC Circ./Assembly Resolution No.	***Description***
MSC/Circ.353	*Guidelines for inert gas systems*
MSC/Circ.387	*Revised guidelines for inert gas systems (MSC/Circ.353), as amended by MSC/Circ.387*
MSC/Circ.450/Rev.1	*Revised factors to be taking into consideration when designing cargo tank venting and gas-freeing arrangements*
MSC/Circ.451	*Guidance concerning the location of fire control plans for assistance of shoreside fire-fighting personnel*
MSC/Circ.485	*Clarification of inert gas system requirements under the Convention*
MSC/Circ. 553	*Information on flashpoint and recommended fire-fighting media for chemicals to which neither the IBC nor BCH Codes apply*
MSC/Circ.582 Corr.1	*Guidelines for performance and testing criteria and surveys of low expansion foam concentrates for fire-extinguishing systems*
MSC/Circ.608/Rev.1	*Interim guidelines for open-top containerships*
MSC/Circ.670	*Guidelines for performance and testing criteria and surveys of high expansion foam concentrates for fire-extinguishing systems*
MSC/Circ.671	*List of solid bulk cargoes which are non-combustible or constitute a low fire risk or for which a fixed gas fire-extinguishing system is ineffective*
MSC/Circ.777	*Indication of the "assembly stations" in passenger ships*
MSC/Circ.798	*Guidelines for the performance and testing criteria, and surveys of medium expansion foam concentrates for fixed fire-extinguishing systems*
MSC/Circ.799	*Guidelines for performance and testing criteria and surveys of expansion foam concentrates for fire extinguishing systems for chemical tankers*
MSC/Circ.848 amended by MSC.1/Circ.1267	*Revised guidelines for the approval of equivalent fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces and cargo pump rooms*
MSC/Circ.849	*Guidelines for the performance, location, use and care of emergency escape breathing devices*
MSC/Circ.850	*Guidelines on maintenance and inspection of fire protection systems and appliances*
MSC/Circ.909	*Interim Guidelines for a simplified evacuation analysis of ro-ro passenger ships*
MSC/Circ.913	*Guidelines for the approval of fixed water-based local application fire-fighting systems for use in category A machinery spaces*
MSC/Circ.917	*"Guidelines on fire safety construction in accommodation areas"*
MSC/Circ.1002	*Guidelines on alternative design and arrangements for fire safety*
MSC/Circ.1165 Amended MSC.1/Circ.1237 and MSC.1/Circ.1269	*Revised guidelines for the approval of fixed water based fire extinguishing systems for machinery spaces and cargo pump rooms*
MSC.1/Circ.1242	*Guidelines for the approval of fixed fire detection and fire alarm systems for cabin balconies*
MSC.1/Circ.1266	*Document of compliance with the special requirements for ships carrying dangerous goods under the provisions of regulation II-2/19 SOLAS 74, as amended*
MSC.1/Circ.1268	*Guidelines for the approval of fixed pressure water spraying and water based fire extinguishing systems for cabin balconies*

MSC Circ./Assembly Resolution No.	***Description***
MSC.1/Circ.1272	*Guidelines when approving alternative fixed water-based fire-fighting systems for use in special category spaces*
MSC.1/Circ/1275	*Unified interpretations of SOLAS Chapter II-2 on the number and arrangement of portable fire extinguishers on board ships*
MSC.1/Circ.1276	*Unified interpretations of SOLAS Ch.II-2*
MSC.1/Circ.1320	*Guidelines for the drainage of fire-fighting water from closed vehicle and ro-ro spaces and special category spaces of passenger and cargo ships*
A.123(V)	*Recommendation on fixed fire-extinguishing systems for special cargo spaces*
A.434(XI)	*Code of safe practice of solid bulk cargoes (BC Code)*
A.565(14)	*Recommended procedures to prevent the illegal or accidental use of low flashpoint cargo oil as fuel*
A.567(14)	*Regulation for inert gas systems on chemical tankers*
A.654(16)	*Graphical symbols for fire control plans*
A.752(18)	*Guidelines for the evaluation, testing and application of low-location lighting on passenger ships*
A.754(18)	*Recommendation on fire resistance tests for 'A', 'B' and 'F' class divisions*
A.756(18)	*Guidelines on the information to be provided with fire control plans and booklets*
A.760(18)	*Symbols related to life-saving appliances and arrangements*
A.800(19)	*Guidelines for approval of sprinkler systems*
A.830(19)	*Fire alarm signalling systems in passenger ships*
A.951(23)	*Improved guidelines for marine portable fire extinguishers*
Note : The above MSC Circulars/Assembly Resolutions are available on the IMO Website www.docs.imo.org. IRS may also be contacted if necessary.	

End of Chapter

Chapter 2

Prevention of Fire and Explosion

Contents

Section 1

Probability of Ignition

1.1 Purpose

The purpose of this section is to prevent the ignition of combustible materials or flammable liquids. For this purpose the following functional requirements are to be met:

.1 means are to be provided to control leaks of flammable liquids;

.2 means are to be provided to limit the accumulation of flammable vapours;

.3 the ignitability of combustible materials is to be restricted;

.4 ignition sources are to be restricted;

.5 ignition sources are to be separated from combustible materials and flammable liquids; and

.6 the atmosphere in cargo tanks is to be maintained out of the explosive range.

1.2 Arrangements for oil fuel, lubrication oil and other flammable oils

1.2.1 Limitations in the use of oils as fuel

The following limitations are to apply to the use of oil as fuel:

.1 except as otherwise permitted by this paragraph, no oil fuel with a flashpoint of less than 60°C is to be used; (Refer to IMO Resolution A.565(14));

.2 in emergency generators oil fuel with a flashpoint of not less than 43°C may be used;

.3 the use of oil fuel having a flashpoint of less than 60°C but not less than 43°C may be permitted (e.g. for feeding the emergency fire pump's engines and the auxiliary machines which are not located in the machinery spaces of category A) subject to the following:

.3.1 fuel oil tanks except those arranged in double bottom compartments are to be located outside the machinery spaces of category A;

.3.2 provisions for the measurement of oil temperature are provided on the suction pipe of the oil fuel pump;

.3.3 stop valves and/or cocks are provided on the inlet side and outlet side of the oil fuel strainers; and

.3.4 pipe joints of welded construction or of circular cone type or spherical type union joint are applied as much as possible; and

.4 in cargo ships the use of fuel having a lower flashpoint than otherwise specified in 1.2.1, for example crude oil, may be permitted provided that such fuel is not stored in any machinery space and subject to the approval of the complete installation by IRS.

1.2.2 Arrangements for oil fuel

In a ship in which oil fuel is used, the arrangements for the storage, distribution and utilization of the oil fuel are to be such as to ensure the safety of the ship and persons on board and are to at least comply with the following provisions.

1.2.2.1 Location of oil fuel systems

As far as practicable, parts of the oil fuel system containing heated oil under pressure exceeding 0.18 [N/mm^2] are not to be placed in a concealed position such that defects and leakage cannot readily be observed. The machinery spaces in way of such parts of the oil fuel system are to be adequately illuminated.

1.2.2.2 Ventilation of machinery spaces

The ventilation of machinery spaces is to be sufficient under normal conditions to prevent accumulation of oil vapour. Also refer Pt.4, Ch.1, Sec.2.4.

1.2.2.3 Oil fuel tanks

.1 Fuel oil, lubrication oil and other flammable oils are not be carried in forepeak tanks, Also refer Pt.3, Ch.10, Cl.2.7.1.

.2 As far as practicable, oil fuel tanks are to be part of the ship's structure and are to be located outside machinery spaces of category A. Where oil fuel tanks, other than double bottom tanks, are necessarily located adjacent to or within machinery spaces of category A, at least one of their vertical sides is to be contiguous to the machinery space boundaries and they are preferably to have a common boundary with the double bottom tanks and the area of the tank boundary common with the machinery spaces are to be kept to a minimum. Where such tanks are situated within the boundaries of machinery spaces of category A they are not to contain oil fuel having a flashpoint of less than 60°C. In general, the use of free-standing oil fuel tanks is to be avoided. When such tanks are employed their use is to be prohibited in category A machinery spaces on passenger ships. Where permitted, they are to be placed in an oil-tight spill tray of ample size having a suitable drain pipe leading to a suitably sized spill oil tank.

.3 No oil fuel tank is to be situated where spillage or leakage therefrom can constitute a fire or explosion hazard by falling on heated surfaces.

.4 For pipes connected to tanks, refer Pt.4, Ch.3, Cl.4.4.4, 4.4.5, 4.4.6.

.5 Safe and efficient means of ascertaining the amount of oil fuel contained in any oil fuel tank are to be provided. For details, refer Pt.4, Ch.3, Sec.3.4.

.5.1 Where sounding pipes are used, they are not to terminate in any space where the risk of ignition of spillage from the sounding pipe might arise. In particular, they are not to terminate in passenger or crew spaces. As a general rule, they are not to terminate in machinery spaces. However, where IRS considers that these latter requirements are impracticable, sounding pipes may terminate in machinery spaces subject to following requirements being met:

a) an oil-level gauge is provided meeting the requirements of .5.2 below;

b) the sounding pipes terminate in locations remote from ignition hazards unless precautions are taken, such as the fitting of effective screens, to prevent the oil fuel in the case of spillage through the terminations of the sounding pipes from coming into contact with a source of ignition; and

c) the termination of sounding pipes are fitted with self-closing blanking devices and with a small-diameter self-closing control cock located below the blanking device for the purpose of ascertaining before the blanking device is opened that oil fuel is not present. Provisions are to be made so as to ensure that any spillage of oil fuel through the control cock involves no ignition hazard.

(Also refer Pt.4, Ch.3, 3.4.3 and 3.4.4).

IR.5.1.1 Oil level gauge referred at .5.1a) above need not be provided for tanks (other than double bottom tanks) having overflow system.

IR.5.1.2 The short sounding pipes are to be arranged in such a way that overflow or oil spray will not reach the vicinity of any of the machinery components like boilers, preheaters, heated surfaces, electric generators or motors with commutator or collector rings or electric appliances.

IR.5.1.3 The self-closing blanking devices are to be cocks having cylindrical plugs with weight loaded levers permanently attached and with approved arrangements for opening.

.5.2 Other oil-level gauges may be used in place of sounding pipes as per details given in Pt.4, Ch.3, Cl.3.4.2.

.5.3 The means prescribed in paragraph .5.2 above are to be maintained in the proper condition to ensure their continued accurate functioning in service.

1.2.2.4 Prevention of overpressure

Provisions are to be made to prevent overpressure in any oil tank or in any part of the oil fuel system, including the filling pipes served by pumps on board. Air and overflow pipes and relief valves are to discharge to a position where there is no risk of fire or explosion from the emergence of oils and vapour and are not to lead into crew spaces, passenger spaces nor into special category spaces, closed ro-ro cargo spaces, machinery spaces or similar spaces. Also refer Pt.4, Ch.3, Sections 3 and 4.

1.2.2.5 Oil fuel piping

.1 Oil fuel pipes and their valves and fittings are to be of steel or other approved material, except that restricted use of flexible pipes are permissible in positions where IRS is satisfied that they are necessary. Such flexible pipes and end attachments are to be of approved fire-resisting materials of adequate strength and are to be constructed to the satisfaction of IRS. For valves, fitted to oil fuel tanks and which are under static pressure, steel or spheroidal-graphite cast iron may be accepted. However, ordinary cast iron valves may be used in piping systems where the design pressure is lower than 7 bar and the design temperature is below 60°C.

.2 For jacketing of external high-pressure fuel delivery lines between the high-pressure fuel pumps and fuel injectors, refer Pt.4, Ch.4, Sec.4.8.5.

.3 Oil fuel lines are not to be located immediately above or near units of high temperature including boilers, steam pipelines, exhaust manifolds, silencers or other equipment required to be insulated by 1.2.2.6. As far as practicable, oil fuel lines are to be arranged far away from hot surfaces, electrical installations or other sources of ignition and are to be screened or otherwise suitably protected to avoid oil spray or oil leakage onto the sources of ignition. The number of joints in such piping systems are to be kept to a minimum.

.4 For requirements for components of diesel engine fuel system refer Pt.4, Ch.4, 4.5.8.2.

.5 For multi-engine installations which are supplied from the same fuel source, refer to Pt.4, Ch.3, 4.10.2.4.

.6 For piping through accommodation and service spaces, refer Pt.4, Ch.3, 4.3.10.

1.2.2.6 Protection of high temperature surfaces

Refer Pt.4, Ch.1, Sec.2.3.

1.2.3 Arrangements for lubricating oil

1.2.3.1 The arrangements for the storage, distribution and utilization of oil used in pressure lubrication systems are to be such as to ensure the safety of the ship and persons onboard. The arrangements made in machinery spaces of category A and whenever practicable in other machinery spaces are at least to comply with the provisions of paragraphs 1.2.2.1, 1.2.2.3.3, 1.2.2.3.4, 1.2.2.3.5, 1.2.2.4, 1.2.2.5.1, 1.2.2.5.3 and 1.2.2.6, except that:

a) this does not preclude the use of sight-flow glasses in lubricating systems provided that they are shown by testing to have a suitable degree of fire resistance; and

b) sounding pipes may terminate in machinery spaces; however, the requirements of 1.2.2.3.5.1a) and 1.2.2.3.5.1.c) need not be applied on condition that the sounding pipes are fitted with appropriate means of closure.

1.2.3.2 For valves on lubricating oil tanks, refer to Pt.4, Ch.3, 8.6.1.

1.2.4 Arrangements for other flammable oils

1.2.4.1 The arrangements for the storage, distribution and utilization of other flammable oils employed under pressure in power transmission systems, control and activating systems and heating systems are to be such as to ensure the safety of the ship and persons onboard. Suitable oil collecting arrangements for leaks are to be fitted below hydraulic valves and comply with the provisions of 1.2.2.3.3, 1.2.2.3.5, 1.2.2.5.3 and 1.2.2.6 and with the provisions of 1.2.2.4 and 1.2.2.5.1 in respect of strength and construction.

1.2.5 Arrangements for oil fuel in periodically unattended machinery spaces

In addition to the requirements of 1.2.1 to 1.2.4, the oil fuel and lubricating oil systems in a periodically unattended machinery space are to comply with the following:

a) where daily service oil fuel tanks are filled automatically, or by remote control, means are to be provided to prevent overflow spillages. Other equipment which treat flammable liquids automatically (e.g. oil fuel purifiers) which, whenever practicable, are to be installed in a special space reserved for purifiers and their heaters are to have arrangements to prevent overflow spillages;

and

b) where daily service oil fuel tanks or settling tanks are fitted with heating arrangements, a high temperature alarm is to be provided if the flashpoint of the oil fuel can be exceeded.

1.3 Arrangements for gaseous fuel for domestic purpose

1.3.1 Gaseous fuel systems used for domestic purposes are to be approved by IRS. Storage of gas bottles are to be located on the open deck or in a well-ventilated space which opens only to the open deck.

IR1.3.1 A portion of open deck, recessed into a deck structure, machinery casing, deck house, etc., utilized for the exclusive storage of gas bottles is considered acceptable for the purpose of 1.3.1 provided that:

.1 such a recess has an unobstructed opening, except for small appurtenant structures, such as opening corner radii, small sills, pillars, etc. The opening may be provided with grating walls and door;

.2 the depth of such a recess is not greater than 1 m.

A portion of open deck meeting the above is to be considered as open deck in applying tables 3.1 to 3.8 of Ch.3.

1.4 Miscellaneous items of ignition sources and ignitability

1.4.1 Electric radiators

1.4.1.1 Electric radiators, if used are to be fixed in position and so constructed as to reduce fire risks to a minimum. No such radiators are to be fitted with an element so exposed that clothing, curtains, or other similar materials can be scorched or set on fire by heat from the element.

1.4.2 Waste receptacles

1.4.2.1 Waste receptacles are to be constructed of non-combustible materials with no openings in the sides or bottom.

IR1.4.2.1 Waste receptacles of combustible materials may however be used in galleys, pantries, bars, garbage handling or storage spaces and incinerator rooms provided they are intended purely for the carriage of wet waste, glass bottles and metal cans and are suitably marked.

1.4.3 Insulation surfaces protected against oil penetration

1.4.3.1 In spaces where penetration of oil products is possible, the surface of insulation is to be impervious to oil or oil vapours. Also refer Pt.4, Ch.1, Cl. 2.3.1.

1.4.4 Primary deck coverings

1.4.4.1 Primary deck coverings, if applied, within accommodation and service spaces and control stations or if applied on cabin balconies of passenger ships constructed on or after 1 July 2008 are to be of an approved material which will not readily ignite, or give rise to toxic or explosive hazards at elevated temperatures, this being determined in accordance with the Fire Test Procedures Code.

1.4.5 Films

1.4.5.1 Cellulose-nitrate based films are not to be used for cinematograph installations.

1.5 Cargo areas of tankers

1.5.1 Separation of cargo oil tanks

1.5.1.1 Cargo pump-rooms, cargo tanks, slop tanks and cofferdams (see Note below) are to be positioned forward of machinery spaces. However, oil fuel bunker tanks need not be forward of machinery spaces. Cargo tanks and slop tanks are to be isolated from machinery spaces by cofferdams, cargo pump-rooms, oil bunker tanks or ballast tanks. Pump-rooms containing pumps and their accessories for ballasting those spaces situated adjacent to cargo tanks and slop tanks and pumps for oil fuel transfer are to be considered as equivalent to a cargo pump-room within the context of these requirements provided that such pump-rooms have the same safety standard as that required for cargo pump-rooms. Pump-rooms intended solely for ballast or oil fuel transfer, however, need not comply with the requirements of Ch.3, Sec.4.9. The lower portion of the pump-room may be recessed into machinery spaces of category A to accommodate pumps, provided that the deck head of the recess is in general not more than one third of the moulded depth above the keel, except that in the case of ships of not more than 25,000 tonnes deadweight, where it can be demonstrated that for reasons of access and satisfactory piping arrangements this is impracticable a recess in excess of such height, but not exceeding one half of the moulded depth above the keel may be permitted.

IR1.5.1.1.1 Pump rooms intended solely for ballast transfer or fuel oil transfer are also not required to comply with the requirement of 1.5.10. The requirements of 1.5.10 are only applicable to the pump-rooms, regardless of their location, where pumps for cargo, such as cargo pumps, stripping pumps, pumps for slop tanks, pumps for COW or similar pumps are provided.
"Similar pumps" includes pumps intended for transfer of fuel oil having a flashpoint of less than 60ºC. Pump rooms intended for transfer of fuel oil having a flashpoint of not less than 60ºC need not comply with the requirements of 1.5.10.

1.5.1.2 Main cargo control stations, control stations, accommodation and service spaces (excluding isolated cargo handling gear lockers) are to be positioned aft of cargo tanks, slop tanks and spaces which isolate cargo or slop tanks from machinery spaces, but not necessarily aft of the oil fuel bunker tanks and ballast tanks and are to be arranged in such a way that a single failure of a deck or bulkhead will not permit the entry of gas or fumes from the cargo tanks into an accommodation space, main cargo control stations, control station, or service spaces. A recess provided in accordance with 1.5.1.1 need not be taken into account when the position of these spaces is being determined.

IR1.5.1.1.2 Void space or ballast water tank protecting fuel oil tank as shown in Fig. 1.1 need not be considered as 'cargo area' defined in Ch.1, 3.6 even though they have a cruciform contact with the cargo oil tank or slop tank.

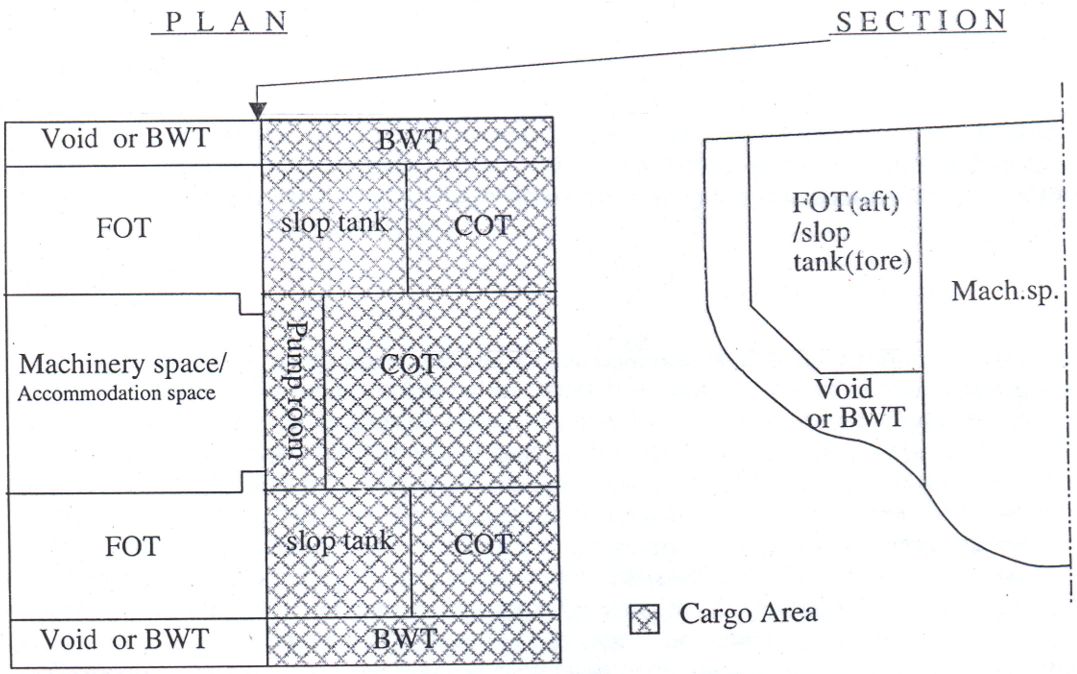

Fig.1.1

BWT ballast water tank

FOT Fuel oil tank

COT Cargo oil tank

1.5.1.3 However, where deemed necessary, IRS may permit main cargo control stations, control stations, accommodation and service spaces forward of the cargo tanks, slop tanks and spaces which isolate cargo and slop tanks from machinery spaces, but not necessarily forward of oil fuel bunker tanks or ballast tanks. Machinery spaces, other than those of category A, may be permitted forward of the cargo tanks and slop tanks provided they are isolated from the cargo tanks and slop tanks by cofferdams, (see Note below) cargo pump-rooms, oil fuel bunker tanks or ballast tanks and have at least one portable fire extinguisher. In cases where they contain internal combustion machinery, one approved foam-type extinguisher of at least 45 l capacity or equivalent is to be arranged in addition to portable fire extinguishers. If operation of a semi-portable fire extinguisher is impracticable, this fire extinguisher may be replaced by two additional portable fire extinguishers. Accommodation spaces, main cargo control spaces, control stations and service spaces are to be arranged in such a way that a single failure of a deck or bulkhead will not permit the entry of gas or fumes from the cargo tanks into such spaces. In addition, where deemed necessary for the safety or navigation of the ship, IRS may permit machinery spaces containing internal combustion machinery not being main propulsion machinery having an output greater than 375 kW to be located forward of the cargo area provided the arrangements are in accordance with the provisions of this clause.

IR1.5.1.3 Paint lockers, regardless of their use are not to be located above the cargo tanks, slop tanks and spaces which isolate cargo or slop tanks from machinery spaces for oil tankers (refer 1.5.1.2) and the cargo area for chemical tankers and liquefied gas carriers.

IR1.5.1.1.3 The void space protecting fuel oil tank is not considered as cofferdam specified in 1.5.1.1 and the void space as shown in Fig. 1.1 is considered acceptable although it has cruciform contact with the slop tank.

1.5.1.4 In combination carriers only: Refer to Pt.5, Ch.2, 12.4.2 to 12.4.5.

1.5.1.5 Where the fitting of a navigation position above the cargo area is shown to be necessary, it is to be for navigation purposes only and it is to be separated from the cargo tank deck by means of an open space with a height of at least 2 m. The fire protection for such a navigation position is to be that required for control stations, as specified in Ch.3, 3.2.4.2 and other provisions for tankers, as applicable.

1.5.1.6 Means are to be provided to keep deck spills away from the accommodation and service areas. This may be accomplished by provision of a permanent continuous coaming of a height of at least 300 [mm], extending from side to side. Special consideration will be given to the arrangements associated with stern loading.

Note: For the purpose of clause 1.5.1 the expression ‘cofferdam’ means an isolating space between two adjacent steel bulkheads or decks. The minimum distance between the two bulkheads or decks is to be sufficient for safe access and inspection. In order to meet the single failure principle, in particular case when a corner-to-corner situation occurs, this principle may be met by welding a diagonal plate across the corner. No cargo, wastes or other goods are to be contained in cofferdams.

1.5.2 Restriction on boundary openings

1.5.2.1 Except as permitted by 1.5.2.2, access doors, air inlets and openings to accommodation spaces, service spaces, control stations and machinery spaces are not to face the cargo area. They are to be located on the transverse bulkhead not facing the cargo area or on the outboard side of the superstructure or deckhouse at a distance of at least 4% of the length of the ship but not less than 3 [m] from the end of the superstructure or deckhouse facing the cargo area. This distance need not exceed 5 [m].

1.5.2.2 IRS may permit access doors in boundary bulkheads facing the cargo area or within the 5 [m] limits specified in 1.5.2.1, to main cargo control stations and to such service spaces used as provision rooms, store-rooms and lockers, provided they do not give access directly or indirectly to any other space containing or providing for accommodation, control stations or service spaces such as galleys, pantries or workshops, or similar spaces containing sources of vapour ignition. The boundary of such a space is to be insulated to "A-60" standard, with the exception of the boundary facing the cargo area. Bolted plates for the removal of machinery may be fitted within the limits specified in 1.5.2.1. Wheelhouse doors and windows may be located within the limits specified in 1.5.2.1 so long as they are designed to ensure that the wheelhouse can be made rapidly and efficiently gas and vapour tight.

IR1.5.2.2

.1 An access to a deck foam system room (including the foam tank and the control station) can be located within the limits mentioned in clause 1.5.2.1, provided that the conditions listed in clause 1.5.2.2 are satisfied and that the door is located flush with the bulkhead.

.2 The navigation bridge external doors and windows which are located within the limits of clause 1.5.2.1 are to be tested for gas-tightness. If a water hose test is applied, the following may be taken as a guide:

- nozzle diameter: minimum 12 [mm];

- water pressure just before the nozzle: not less than 0.2 [N/mm^2]; and
- distance between the nozzles and the doors or windows: max. 1.5 [m].

.3 Access to forecastle spaces containing sources of ignition may be permitted through doors facing cargo area provided the doors are located outside hazardous areas as defined in IEC Publication 60092-502. (Also cross references should be added to Pt.5, Ch.3, 3.2.3 and Pt.5, Ch.4, 3.2.4).

1.5.2.3 Windows and side scuttles facing the cargo area and on the sides of the superstructures and deckhouses within the limits specified in 1.5.2.1 are to be of a fixed (non-opening) type. Such windows and side scuttles, except wheelhouse windows are to be constructed to "A-60" class standard except that “A-0” class standard is acceptable for windows and side scuttles outside the limit specified in Ch.3, 3.2.4.2.5.

1.5.2.4 Where there is permanent access from a pipe tunnel to the main pump-room, a watertight door is to be fitted complying with the requirements of Pt.3, Ch.10, Cl.2.5.2 and in addition, with the following:

.1 in addition to the bridge operation, the watertight door is to be capable of being manually closed from outside the main pump-room entrance; and

.2 the watertight door is to be kept closed during normal operations of the ship except when access to the pipe tunnel is required.

1.5.2.5 Permanent approved gas tight lighting enclosures for illuminating cargo pump rooms may be permitted in bulkheads and decks separating cargo pump rooms ad other spaces provided they are of adequate strength and integrity and gastightness of the bulkhead or deck is maintained.

1.5.2.6 The arrangement of ventilation inlets and outlets and other deckhouse and superstructure boundary space openings are to be such as to complement the provisions of 1.5.3 and Ch.3, 5.6. Such vents, especially for machinery spaces are to be situated as far aft as practicable. Due consideration in this regard is to be given when the ship is equipped to load or discharge at the stern. Sources of ignition such as electrical equipment are to be so arranged as to avoid an explosion hazard.

1.5.3 Cargo tank venting

1.5.3.1 General requirements

Refer to Pt.5, Ch.2, 8.1.1.

1.5.3.2 Venting arrangements

Refer to Pt.5, Ch.2, 8.1.6, 8.1.7 and 8.1.11.

1.5.3.3 Safety devices in venting systems

Refer to Pt.5, Ch.2, 8.1.12.

1.5.3.4 Vent outlets for cargo handling and ballasting

1.5.3.4.1 For vent outlets for cargo loading, discharging and ballasting required by Ch.3, 5.6.1.2, refer to Pt.5, Ch.2, 8.1.15 and 8.1.16.

1.5.3.5 Slop tanks in combination carriers

Refer to Pt.5, Ch.2, 12.4.4.

1.5.4 Ventilation

1.5.4.1 Ventilation systems in cargo pump-rooms

Cargo pump-rooms are to be mechanically ventilated and discharges from the exhaust fans are to be led to a safe place on the open deck. The ventilation of these rooms is to have sufficient capacity to minimize the possibility of accumulation of flammable vapours. The number of air changes is to be at least 20 per hour, based upon the gross volume of the space. The air ducts are to be arranged so that all of the space is effectively ventilated. The ventilation is to be of the suction type using fans of the non-sparking type. (Also refer Pt.5, Ch.2, Cl.6.1).

1.5.4.2 Ventilation systems in combination carriers

In combination carriers, cargo spaces and any enclosed spaces adjacent to cargo spaces are to be capable of being mechanically ventilated. The mechanical ventilation may be provided by portable fans. An approved fixed gas warning system capable of monitoring flammable vapours is to be provided in cargo pump-rooms, pipe ducts and cofferdams, as referred to in 1.5.1.4, adjacent to slop tanks. Suitable arrangements are to be made to facilitate measurement of flammable vapours in all other spaces within the cargo area. Such measurements are to be made possible from the open deck or easily accessible positions.

1.5.5 Inert gas systems

1.5.5.1 Application

1.5.5.1.1 For tankers of 20,000 tonnes deadweight and upwards constructed on or after 1 July 2002 but before 1 January 2016, the protection of the cargo tanks is to be achieved by a fixed inert gas system in accordance with the requirements of the Fire Safety Systems Code, as adopted by resolution MSC.98(73), except that the Administration may accept other equivalent systems or arrangements, as described in paragraph 1.5.5.4.

1.5.5.1.2 For tankers of 8,000 tonnes deadweight and upwards constructed on or after 1 January 2016 when carrying cargoes described in Pt 6, Ch 1, 1.5.1 or 1.5.2, the protection of the cargo tanks is to be achieved by a fixed inert gas system in accordance with the requirements of Pt 6, Ch 8, except that the Administration may accept other equivalent systems or arrangements, as described in paragraph 1.5.5.4.

1.5.5.1.3 Tankers operating with a cargo tank cleaning procedure using crude oil washing are to be fitted with an inert gas system complying with Pt 6, Ch 8 and with fixed tank washing machines. However, inert gas systems fitted on tankers constructed on or after 1 July 2002 but before 1 January 2016 are to comply with the Fire Safety Systems Code, as adopted by resolution MSC.98(73).

1.5.5.1.4 Tankers required to be fitted with inert gas systems are to comply with the following provisions:

.1 double-hull spaces are to be fitted with suitable connections for the supply of inert gas;

.2 where hull spaces are connected to a permanently fitted inert gas distribution system, means are to be provided to prevent hydrocarbon gases from the cargo tanks entering the double hull spaces through the system; and

.3 where such spaces are not permanently connected to an inert gas distribution system, appropriate means are to be provided to allow connection to the inert gas main.

1.5.5.2 Inert gas systems of chemical tankers and gas carriers

1.5.5.2.1 The requirements for inert gas systems contained in the Pt.5, Ch.2, Sec.11 , Pt.6 Ch.8 and FSS Code need not be applied to chemical tankers constructed before 1 January 2016, including those constructed before 1 July 2012, and all gas carriers:

.1 when carrying cargoes described in Ch.1, 1.6.1, provided that they comply with the requirements for inert gas systems on chemical tankers approved by the National Statutory Authority (refer to the regulations for inert gas systems on chemical tankers adopted by IMO Resolution A.567(14) Corr.1)

or

.2 when carrying flammable cargoes other than crude oil or petroleum products such as cargoes listed in Sections 17 and 18 of Pt.5, Ch.3, provided that the capacity of tanks used for their carriage does not exceed 3,000 [m^3] and the individual nozzle capacities of tank washing machines do not exceed 17.5 [m^3/h] and the total combined throughput from the number of machines in use in a cargo tank at any one time does not exceed 110 [m^3/h].

1.5.5.3 General requirements for inert gas systems

.1 The inert gas system is to be capable of inerting, purging and gas-freeing empty tanks and maintaining the atmosphere in cargo tanks with the required oxygen content.

.2 Tankers fitted with a fixed inert gas system are to be provided with a closed ullage system.

1.5.5.4 Requirements for equivalent systems

1.5.5.4.1 For tankers of 8,000 tonnes deadweight and upwards but less than 20,000 tonnes deadweight , in lieu of fixed installations , IRS may accept other equivalent arrangements or means of protection in accordance with paragraph 1.5.5.4.2.

1.5.5.4.2 Equivalent systems or arrangements are to :

.1 be capable of preventing dangerous accumulations of explosive mixtures in intact cargo tanks during normal service throughout the ballast voyage and necessary in-tank operations; and

.2 be so designed as to minimize the risk of ignition from the generation of static electricity by the system itself.

1.5.6 Inerting, purging and gas-freeing (Also refer Pt.5, Ch.2, 8.2)

.1 Arrangements for purging and/or gas-freeing are to be such as to minimize the hazards due to dispersal of flammable vapours in the atmosphere and to flammable mixtures in a cargo tank.

.2 The procedure for cargo tank purging and/or gas-freeing are to be carried out in accordance with Ch.5, 3.3.2.

.3 Also refer to Pt.5, Ch.2, 8.2.3.

1.5.7 Gas measurement

1.5.7.1 Portable instrument

Refer to Pt.5, Ch.2, 8.2.6.

1.5.7.2 Arrangements for gas measurement in double hull and double bottom spaces

Refer to Pt.5, Ch.2, 8.3.3, 8.3.4 and 8.3.5.

1.5.8 Air supply to double hull and double bottom spaces

Double hull and double bottom spaces are to be fitted with suitable connections for the supply of air.

1.5.9 Protection of cargo area

Drip pans of suitable material for collecting cargo residues in cargo lines and hoses are to be provided in the area of pipe and hose connections under the manifold area. Cargo hoses and tank washing hoses are to have electrical continuity over their entire lengths including couplings and flanges (except shore connections) and are to be earthed for removal of electrostatic charges.

1.5.10 Protection of cargo pump rooms

1.5.10.1 For details of protection in tankers; Refer Pt.5, Ch.2, 6.4.2 to 6.4.5 and IR6.4.5.

Section 2

Fire Growth Potential

2.1 Purpose

2.1.1 The purpose of this regulation is to limit the fire growth potential in every space of the ship. For this purpose, the following functional requirements are to be met:

a) means of control for the air supply to the space are to be provided;

b) means of control for flammable liquids in the space are to be provided; and

c) the use of combustible materials is to be restricted.

2.2 Control of air supply and flammable liquid to the space

2.2.1 Closing appliances and stopping devices of ventilation

2.2.1.1 The main inlets and outlets of all ventilation system are to be capable of being closed from outside the spaces being ventilated. The means of closing are to be easily accessible as well as prominently and permanently marked and are to indicate whether the shut-off is open or closed.

IR2.2.1.1 Battery room ventilators are to be fitted with a means of closing under the following conditions:

i) The battery room does not open directly onto an exposed deck; or

ii) The ventilation opening for the battery room is required to be fitted with a closing device according to the Pt.3, Ch.13, Cl.2.3.1 (i.e. the height of the opening does not extend to more than 4.5 [m] (14.8 feet) above the deck for position 1 or to more than 2.3 [m] (7.5 feet) above the deck in position 2; or

iii) The battery room is fitted with a fixed gas fire extinguishing system.

Where a battery room ventilator is fitted with a closing device, a warning notice stating, for example “This closing device is to be kept open and closed only in the event of fire or other emergency – Explosive gas”, is to be provided at the closing device to mitigate the possibility of inadvertent closing.

Also refer Pt.4, Ch.8, Cl.7.1.5.

2.2.1.2 Power ventilation of accommodation spaces, service spaces, cargo spaces, control stations and machinery spaces are to be capable of being stopped from an easily accessible position outside the space being served. This position is not to be readily cut off in the event of a fire in the spaces served.

2.2.1.3 In passenger ships carrying more than 36 passengers, power ventilation, except machinery space and cargo space ventilation and any alternative system which may be required by Ch.3, 2.2 is to be fitted with controls so grouped that all fans may be stopped from either of two separate positions which are to be situated as far apart as practicable. Fans serving power ventilation systems to cargo spaces are to be capable of being stopped from a safe position outside such spaces.

IR2.2.1.3 The fan in a HVAC temperature control unit, or a circulation fan inside a cabinet/switchboard, is not considered to be a ventilation fan as addressed in 2.2.1.2, 2.2.1.3 and Ch 3, 1.9.3, if it is not capable of supplying outside air to the space when the power ventilation is shut down (e.g., small units intended for re-circulation of air within a cabin). Therefore, such fans need not be capable of being stopped from an easily accessible position (or a safe position) outside the space being served when applying 2.2.1.2 or 2.2.1.3, and need not be capable of being controlled from a continuously manned central control station for passenger ships carrying more than 36 passengers when applying Ch 3, 1.9.3.

2.2.2 Means of control in machinery spaces

2.2.2.1 Means of control are to be provided for opening and closure of skylights, closure of openings in funnels which normally allow exhaust ventilation and closure of ventilator dampers.

IR2.2.2.1 Ventilation inlets and outlets located at outside boundaries are to be fitted with closing appliances as required by 2.2.2.1 but need not comply with Ch.3, 3.7.3.1.

2.2.2.2 Means of control are to be provided for stopping ventilating fans. Controls provided for the power ventilation serving machinery spaces are to be grouped so as to be operable from two positions, one of which is to be outside such spaces. The means provided for stopping the power ventilation of the machinery spaces are to be entirely separate from the means provided for stopping ventilation of other spaces.

2.2.2.3 Means of control are to be provided for stopping forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pumps, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers). However, 2.2.2.4 and 2.2.2.5 need not apply to oily water separators.

2.2.2.4 The controls required in 2.2.2.1 to 2.2.2.3 and in 1.2.2.3.4 are to located outside the space concerned so they will not be cut off in the event of fire in the space they serve.

2.2.2.5 In passenger ships, the controls required in 2.2.2.1 to 2.2.2.4 and in Ch.3, 2.3.3 and Ch.3, 3.5.2.3 and the controls for any required fire-extinguishing system are to be situated at one control position or grouped in as few positions as possible to the satisfaction of IRS. Such positions are to have a safe access from the open deck.

2.2.3 Additional requirements for means of control in periodically unattended machinery spaces

2.2.3.1 For periodically unattended machinery spaces, special consideration will be given to maintaining the fire integrity of the machinery spaces, the location and centralization of the fire-extinguishing system controls, the required shutdown arrangements (e.g. ventilation, fuel pumps, etc.) and that additional fire-extinguishing appliances and other fire-fighting equipment and breathing apparatus may be required.

2.2.3.2 In passenger ships, these requirements are be at least equivalent to those of machinery spaces normally attended.

2.3 Fire protection materials

2.3.1 Use of non-combustible materials

2.3.1.1 Insulating materials

Insulating materials are to be non-combustible, except in cargo spaces, mail rooms, baggage rooms and refrigerated compartments of service spaces. Vapour barriers and adhesives used in conjunction with insulation, as well as the insulation of pipe fittings for cold service systems, need not be of non-combustible materials, but they are to be kept to the minimum quantity practicable and their exposed surfaces are to have low flame-spread characteristics.

IR2.3.1.1 Cold service in 2.3.1.1 is understood to mean refrigeration systems and chilled water piping for air-conditioning systems.

2.3.1.2 Ceilings and linings

.1 In passenger ships, all linings, grounds, draught stops and ceilings are to be of non-combustible material in the following spaces except in mailrooms, baggage rooms and saunas and refrigerated compartments of service spaces:

a) accommodation spaces, service spaces and control stations
b) stairways, open deck spaces
c) machinery spaces.

.2 In cargo ships, all linings, ceilings, draught stops and their associated grounds are to be of non-combustible materials in the following spaces:

a) in accommodation and service spaces and control stations for ships where Method IC is specified as referred to in Ch.3, 3.2.3.1; and

b) in corridors and stairway enclosures serving accommodation and service spaces and control stations for ships where Method IIC and IIIC are specified as referred to in Ch.3, 3.2.3.1.

2.3.1.3 Partial bulkheads and decks on passenger ships

.1 Partial bulkheads or decks used to subdivide a space for utility or artistic treatment are to be of non-combustible material.

.2 Linings, ceilings or partial bulkheads or decks used to screen or to separate adjacent cabin balconies are to be of non-combustible materials. Cabin balconies on passenger ships constructed before 1 July 2008 are to comply with the requirements of this clause by the first survey after 1 July 2008.

2.3.2 Use of combustible materials

2.3.2.1 General

.1 In passenger ships, "A", "B" or "C" class divisions in accommodation and services spaces and cabin balconies which are faced with combustible materials, facings, mouldings, decorations and veneers are to comply with the provisions of 2.3.2.2 to 2.3.2.4 and section 3. However, traditional wooden benches and wooden linings on bulkheads and ceilings are permitted in saunas and such materials need not be subject to the calculations prescribed in 2.3.2.2 and 2.3.2.3. However, the provisions of 2.3.2.3 need not be applied to cabin balconies.

.2 In cargo ships, non-combustible bulkheads, ceilings and linings fitted in accommodation and service spaces may be faced with combustible materials, facings, mouldings, decorations and veneers provided such spaces are bounded by non-combustible bulkheads, ceilings and linings in accordance with the provisions of 2.3.2.2 to 2.3.2.4 and Section 3.

2.3.2.2 Maximum calorific value of combustible materials

Combustible materials used on the surfaces and linings specified in 2.3.2.1 are to have a calorific value not exceeding 45 [MJ/m^2] of the area for the thickness used. The requirements of this paragraph are not applicable to the surfaces of furniture fixed to linings or bulkheads. (Refer ISO 1716:1973 on Determination of Calorific value).

2.3.2.3 Total volume of combustible materials

Where combustible materials are used in accordance with 2.3.2.1, they are to comply with the following requirements:

a) The total volume of combustible facings mouldings, decorations and veneers in accommodation and service spaces are not to exceed a volume equivalent to 2.5 [mm] veneer on the combined area of the walls and ceiling linings. Furniture fixed to linings, bulkheads or decks need not be included in the calculation of the total volume of combustible materials; and

b) In the case of ships fitted with an automatic sprinkler system complying with the provisions of the Fire Safety Systems Code (Chapter 8), the above volume may include some combustible material used for erection of "C" class divisions.

2.3.2.4 Low flame-spread characteristics of exposed surfaces

The following surfaces are to have low flame-spread characteristics in accordance with the Fire Test Procedures Code:

.1 In passenger ships:

a) exposed surfaces in corridors and stairway enclosures and of bulkhead and ceiling linings in accommodation and service spaces (except saunas) and control stations; and
b) surfaces and grounds in concealed or inaccessible spaces in accommodation and service spaces and control stations.

c) Exposed surfaces of cabin balconies, except for natural hard wood decking systems.

.2 In cargo ships:

a) exposed surfaces in corridors and stairway enclosures and of ceilings in accommodation and service spaces (except saunas) and control stations; and

b) surfaces and grounds in concealed or inaccessible spaces in accommodation and service spaces and control stations.

2.3.3 Furniture in stairway enclosures of passenger ships

Furniture in stairway enclosures are to be limited to seating. It is to be fixed, limited to six seats on each deck in each stairway enclosure, be of restricted fire risk determined in accordance with the Fire Test Procedure Code, and is not to restrict the passenger escape route. Additional seating may be permitted in the main reception area within a stairway enclosure if it is fixed, non-combustible and does not restrict the passenger escape route. Furniture is not to be fixed in passenger and crew corridors forming escape routes in cabin areas. In addition to the above, lockers of non-combustible material, providing storage for non-hazardous safety equipment required by these rules, may be permitted. Drinking water dispensers and ice cube machines may be fixed in corridors provided they are fixed and do not restrict the width of the escape routes. This applies as well to decorative flower or plant arrangements, statues or other objects of art such as paintings and tapestries in corridors and stairways.

2.3.4 Furniture and furnishings on cabin balconies of passenger ships

On passenger ships, furniture and furnishings on cabin balconies are to comply with requirements of Ch.1, 3.40 a), b), c), f) and g) unless such balconies are protected by a fixed pressure water-spraying and fixed fire detection and fire alarm systems complying with Ch.3, 1.10 and Ch.3, 4.6.1.3. passenger ships constructed before 1 July 2008 are to comply with the requirements of this clause by the first survey after 1 July 2008.

Section 3

Smoke Generation Potential and Toxicity

3.1 Purpose

3.1.1 The purpose of this section is to reduce the hazard to life from smoke and toxic products generated during a fire in spaces where persons normally work or live. For this purpose, the quantity of smoke and toxic products released from combustible materials, including surface finishes, during fire is to be limited.

3.2 Paints, varnishes and other finishes

The following requirements apply to accommodation spaces, service spaces and control stations as well as stairway enclosures.

3.2.1 Paints, varnishes and other finishes used on exposed interior surfaces are not be capable of producing excessive quantities of smoke and toxic products, this being determined in accordance with the Fire Test Procedures Code.

3.2.2 On passenger ships constructed on or after 1 July 2008, paints, varnishes and other finishes used on exposed surfaces of cabin balconies, excluding natural hard wood decking systems, are not to be capable of producing excessive quantities of smoke and toxic products, this being determined in accordance with the Fire Test Procedures Code.

3.3 Primary deck coverings

3.3.1 Primary deck coverings, if applied within accommodation and service spaces and control stations are to be of approved material which will not give rise to smoke or toxic or explosive hazards at elevated temperatures, this being determined in accordance with the Fire Test Procedures Code.

3.3.2 On passenger ships constructed on or after 1 July 2008, primary deck coverings on cabin balconies are not to give rise to smoke, toxic or explosive hazards at elevated temperatures, this being determined in accordance with the Fire Test Procedures Code.

3.4 Asbestos

3.4.1 For all ships, new installations of materials which contain asbestos are prohibited.

End of Chapter

Chapter 3

Suppression of Fire

Contents

Section

Section 1

Detection and Alarm

1.1 Purpose

1.1.1 The purpose of this section is to detect a fire in the space of origin and to provide for alarm for safe escape and fire-fighting activity. For this purpose, the following functional requirements are to be met:

a) fixed fire detection and fire alarm system installations are to be suitable for the nature of the space, fire growth potential and potential generation of smoke and gases;

b) manually operated call points are to be placed effectively to ensure a readily accessible means of notification; and

c) fire patrols are to provide an effective means of detecting and locating fires and alerting the navigation bridge and fire teams.

1.2 General requirements

1.2.1 A fixed fire detection and fire alarm system is to be provided in accordance with the provisions of this section.

1.2.2 A fixed fire detection and fire alarm system and a sample extraction smoke detection system required in this section and other sections in this chapter are to be of an approved type and comply with the Fire Safety Systems Code (Chapter 8).

1.2.3 Where a fixed fire detection and fire alarm system is required for the protection of spaces other than those specified in 1.5.1, at least one detector complying with the Fire Safety Systems Code (Chapter 8) is to be installed in each such space.

1.2.4 A fixed fire detection and fire alarm system for passenger ships is to be capable of remotely and individually identifying each detector and manually operated call point.

1.3 Initial and periodical tests

1.3.1 The function of fixed fire detection and fire alarm systems required by the relevant sections of this part are to be tested under varying conditions of ventilation after installation.

1.3.2 The function of fixed fire detection and fire alarm systems is to be periodically tested to the satisfaction of IRS by means of equipment producing hot air at the appropriate temperature, or smoke or aerosol particles having the appropriate range of density or particle size, or other charateristics associated with incipient fires to which the detector is designed to respond.

1.4 Protection of machinery spaces

IR1.4 This requirement is applicable to machinery spaces of category ‘A’.

1.4.1 Installation

A fixed fire detection and fire alarm system is to be installed in:

.1 periodically unattended machinery spaces;

.2 machinery spaces where:

a) the installation of automatic and remote control systems and equipment has been approved in lieu of continuous manning of the space; and

b) the main propulsion and associated machinery including sources of the main sources of electrical power are provided with various degrees of automatic or remote control and are under continuous manned supervision from a control room and:

c) enclosed spaces containing incinerators.

1.4.2 Design

1.4.2.1 This fire detection system is to be so designed and the detectors so positioned as to detect rapidly the onset of fire in any part of those spaces and under any normal conditions of operation of the machinery and variations of ventilation as required by the possible range of ambient temperatures. Consideration is to be given to avoid false alarms. The arrangement and the number of Sections and the location of detector heads is to be approved in each case. Except in spaces of restricted height and where their use is specially appropriate, detection systems using only thermal detectors will not be permitted. The detection system is to initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire, in sufficient places to ensure that the alarms are heard and observed on the navigating bridge and by a responsible engineer officer. When the navigating bridge is unmanned the alarm is to sound in a place where a responsible member of the crew is on duty. (Also refer Pt.5, Ch.22, 2.13 for other requirements).

1.5 Protection of accommodation and service spaces and control stations

1.5.1 Smoke detectors in accommodation spaces

Smoke detectors are to be installed in all stairways, corridors and escape routes within accommodation spaces as provided in 1.5.2, 1.5.3 and 1.5.4 Consideration will be given to the installation of special purpose smoke detectors within ventilation ducting.

1.5.2 Requirements for passenger ships carrying more than 36 passengers

.1 A fixed fire detection and fire alarm system is to be installed and arranged as to provide smoke detection in service spaces, control stations and accommodation spaces, including corridors, stairways and escape routes within accommodation spaces. Smoke detectors need not be fitted in private bathrooms and galleys. Spaces having little or no fire risk such as voids, public toilets, carbon dioxide rooms and similar spaces need not be fitted with a fixed fire detection and alarm system. Detectors fitted in cabins, when activated are also to be capable of generating or activating an audible alarm within the space where they are located.

IR.2 Heat detectors are acceptable in refrigerated chambers and in other spaces such as saunas and laundries where steam and fumes are emanated.

1.5.3 Requirements for passenger ships carrying not more than 36 passengers

There is to be installed throughout each separate zone, whether vertical or horizontal, in all accommodation and service spaces and where it is considered necessary by IRS, in control stations, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc., either:

.1 a fixed fire detection and fire alarm system so installed and arranged as to detect the presence of fire in such spaces and providing smoke detection in corridors, stairways and escape routes within accommodation spaces. Detectors fitted in cabins, when activated are also to be capable of generating or activating an audible alarm within the space where they are located; or

.2 an automatic sprinkler, fire detection and fire alarm system of an approved type complying with the relevant requirements of the Fire Safety Systems Code (Chapter 8) and so installed and arranged as to protect such spaces and, in addition, a fixed fire detection and fire alarm system and so installed and arranged as to provide smoke detection in corridors, stairways and escape routes within accommodation spaces.

1.5.4 Protection of atriums in passenger ships

The entire main vertical zone containing the atrium is to be protected throughout with a smoke detection system.

1.5.5 Cargo ships

Accommodation and service spaces and control stations of cargo ships are to be protected by a fixed fire detection and fire alarm system and/or an automatic sprinkler, fire detection and fire alarm system as follows depending on a protection method adopted in accordance with Ch.3, 3.2.3.1.

1.5.5.1 Method IC

A fixed fire detection and fire alarm system is to be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces.

1.5.5.2 Method IIC

An automatic sprinkler, fire detection and fire alarm system of an approved type complying with the relevant requirements of the Fire Safety Systems Code (Chapter 8) are to be so installed and arranged as to protect accommodation spaces, galleys and other service spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc. In addition, a fixed fire detection and fire alarm system of an approved type complying with the requirements of Ch.8, Sec.9 is to be so installed and arranged to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces.

1.5.5.3 Method IIIC

A fixed fire detection and fire alarm system is to be so installed and arranged as to detect the presence of fire in all accommodation spaces and service spaces providing smoke detection in corridors, stairways and escape routes within accommodation spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc.

IR1.5.5.3 The above requirement applies to accommodation block. Service spaces built away from accommodation block need not be fitted with a fixed fire detection and fire-alarm system complying with FSS Code (Chapter 8).

1.6 Protection of cargo spaces in passenger ships

A fixed fire detection and fire alarm system or a sample extraction smoke detection system is to be provided in any cargo space which is not accessible, except where it is shown to the satisfaction of IRS that the ship is engaged on voyages of such short duration that it would be unreasonable to apply this requirement.

1.7 Manually operated call points

1.7.1 Manual call points are to be installed throughout the accommodation spaces, service spaces and control stations. One manual call point is to be located at each exit. Manual call points are to be readily accessible in the corridors of each deck such that no part of the corridor is more than 20 [m] from a manual call point.

IR1.7.1 The phrase ‘Manually operated call points complying with the Fire Safety Systems Code are to be installed throughout the accommodation spaces, service spaces and control stations in 1.7.1 above does not require the fitting of a manually operated call point in an individual space within the accommodation spaces, service spaces and control stations. However, a manually operated call point is to be located at each exit (inside or outside) to the open deck from the corridor such that no part of the corridor is more than 20 [m] from a manually operated call point. Service spaces and control stations which have only one access, leading directly to the open deck are to have a manually operated call point not more than 20 [m] (measured along the access route using the deck, stairs and/or corridors) from the exit. A manually operated call point is not required to be installed for spaces having little or no fire risk, such as voids and carbon dioxide rooms, nor at each exit from the navigation bridge, in cases where the control panel (for fixed fire detection and fire alarm system) is located in the navigation bridge.

1.8 Fire patrols in passenger ships

1.8.1 Fire patrols

For ships carrying more than 36 passengers an efficient patrol system is to be maintained so that an outbreak of fire may be promptly detected. Each member of the fire patrol is to be trained to be familiar with the arrangements of the ship as well as the location and operation of any equipment he may be called upon to use.

1.8.2 Inspection hatches

The construction of ceiling and bulkheads is to be such that it will be possible, without impairing the efficiency of the fire protection, for the fire patrols to detect any smoke originating in concealed and inaccessible places, except where there is no risk of fire originating in such places.

1.8.3 Two-way portable radiotelephone apparatus

Each member of the fire patrol is to be provided with a two-way portable radiotelephone apparatus.

1.9 Fire alarm signalling systems in passenger ships (IMO Res.A.830(19) may be referred for Code of Alarms)

1.9.1 Passenger ships are at all times when at sea, or in port (except when out of service), to be so manned or equipped as to ensure that any initial fire alarm is immediately received by a responsible member of the crew.

1.9.2 The control panel of fixed fire detection and fire alarm systems is to be designed on the fail-safe principle (e.g. an open detector circuit is to cause an alarm condition).

1.9.3 Passenger ships carrying more than 36 passengers are to have the fire detection alarms for the systems required by 1.5.2 centralized in a continuously manned central control station. In addition, controls for remote closing of the fire doors and shutting down the ventilation fans are to be centralized in the same location. The ventilation fans are to be capable of reactivation by the crew at the continuously manned control station. The control panels in the central control station are to be capable of indicating open or closed positions of fire doors and closed or off status of the detectors, alarms and fans. The control panels are to be continuously powered and are to have an automatic change-over to standby power supply in case of loss of normal power supply. The control panels are to be powered from the main source of electrical power and the emergency source of electrical power unless other arrangements are permitted by applicable requirements. (Also refer to Ch 2, IR 2.2.1.3)

1.9.4 A special alarm, operated from the navigation bridge or fire control station, is to be fitted to summon the crew. This alarm may be part of the ship's general alarm system and is to be capable of being sounded independently of the alarm to the passenger spaces.

1.10 Protection of cabin balconies on passenger ships

A fixed fire detection and fire alarm system complying with the provisions of Ch.8 is to be installed on cabin balconies of ships to which requirement of Ch.2, 2.3.4 applies, when furniture and furnishings on such balconies are not as defined in Ch.1, 3.40 a), b), c), f) and g).

Section 2

Control of Smoke Spread

2.1 Purpose

The purpose of this regulation is to control the spread of smoke in order to minimize the hazards from smoke. For this purpose, means for controlling smoke in atriums, control stations, machinery spaces and concealed spaces are to be provided.

2.2 Protection of control stations outside machinery spaces

Such measures as practicable are to be taken in respect of control stations outside machinery spaces in order to ensure that ventilation, visibility and freedom from smoke are maintained, so that in the event of fire the machinery and equipment contained therein may be supervised and continue to function effectively. Alternative and separate means of air supply are to be provided; air inlets of the two sources of supply are to be so disposed that the risk of both inlets drawing in smoke simultaneously is minimized. Such requirements need not apply to control station situated on, and opening on to, an open deck, or where local closing arrangements would be equally effective. The ventilation system serving safety centers may be derived from the ventilation system serving the navigation bridge, unless located in an adjacent main vertical zone.

IR2.2 The expression 'local closing arrangements would be equally effective' in 2.2 means that in case of ventilators, the ventilators are fitted with fire dampers or smoke dampers which could be closed easily from within the control station in order to maintain the absence of smoke in the event of fire.

2.3 Release of smoke from machinery spaces

2.3.1 The following requirements are applicable to machinery spaces of category A and, where IRS considers desirable, to other machinery spaces.

2.3.2 Suitable arrangements are to be made to permit the release of smoke, in the event of fire, from the space to be protected, subject to the provisions of 3.5.2.1. The normal ventilation systems may be acceptable for this purpose.

2.3.3 Means of control are to be provided for permitting the release of smoke and such controls are to be located outside the space concerned so that, in the event of fire, they will not be cut off from the space they serve.

2.3.4 In passenger ships, the controls required by 2.3.3 are to be situated at one control position or grouped in as few positions as possible to the satisfaction of IRS. Such positions are to have a safe access from the open deck.

2.4 Draught stops

Air spaces enclosed behind ceilings, panelling or linings are to be divided by close-fitting draught stops spaced not more than 14 [m] apart. In the vertical direction, such enclosed air spaces, including those behind linings of stairways, trunks, etc., are to be closed at each deck.

2.5 Smoke extraction systems in atriums of passenger ships

Atriums are to be equipped with a smoke extraction system. The smoke extraction system is to be activated by the required smoke detection system and be capable of manual control. The fans are to be sized such that the entire volume within space can be exhausted in 10 min or less.

Section 3

Containment of Fire

3.1 Purpose

The purpose of this section is to contain a fire in the space of origin. For this purpose, the following functional requirements are to be met:

.1 the ship is to be subdivided by thermal and structural boundaries;

.2 thermal insulation of boundaries are to have due regard to the fire risk of the space and adjacent spaces; and

.3 the fire integrity of the divisions is to be maintained at openings and penetrations.

3.2 Thermal and structural boundaries

3.2.1 Thermal and structural subdivision

Ships of all types are to be subdivided into spaces by thermal and structural divisions having regard to the fire risks of the space.

3.2.2 Passenger ships

3.2.2.1 *Main vertical zones and horizontal zones*

3.2.2.1.1a) In ships carrying more than 36 passengers, the hull, superstructure and deckhouses are to be subdivided into main vertical zones by 'A-60' class divisions. Steps and recesses are to be kept to a minimum, but where they are necessary, they are also to be 'A-60' class divisions. These standard may be reduced to 'A-0' where one side of the division belong to any of the following categories or where fuel oil tanks are on both sides of the division:

- open deck spaces as per 3.2.2.3.2.2(5)
- sanitary and similar spaces as per 3.2.2.3.2.2(9)
- tanks, voids and auxiliary machinery space having little or no fire risk as per 3.2.2.3.2.2(10).

3.2.2.1.1b) In ships carrying not more than 36 passengers, the hull, superstructure and deckhouses in way of accommodation and service spaces are to be subdivided into main vertical zones by "A" class divisions. These divisions are to have insulation values in accordance with tables in 3.2.2.4.

3.2.2.1.2 As far as practicable the bulkheads forming the boundaries of the main vertical zones above the bulkhead deck are to be in line with watertight subdivision bulkheads situated immediately below the bulkhead deck. The length and width of main vertical zones may be extended to a maximum of 48 [m] in order to bring the ends of main vertical zones to coincide with watertight subdivision bulkheads or in order to accommodate a large public space extending for the whole length of the main vertical zone. The total area of the main vertical zone however, is not to be greater than 1600 [m^2] on any deck. The length and width of a main vertical zone is to be taken as the maximum distance between the furthermost points of the bulkheads bounding it.

IR3.2.2.1.2 If a stairway serves two main vertical zones, the maximum length of one main vertical zone is to be measured from the far side of the main vertical zone stairway enclosure. In this case, all boundaries of the stairway enclosure are to be insulated as main vertical zone bulkheads and access doors leading into the stairway are to be provided from the zones. (See Fig.3.2.2.1 to Fig.3.2.2.4). However, the stairway is not to be included in calculating the size of the main vertical zone if it is treated as its own main vertical zone.

The number of main vertical zones of 48 m length is not limited as long as they comply with all the requirements.

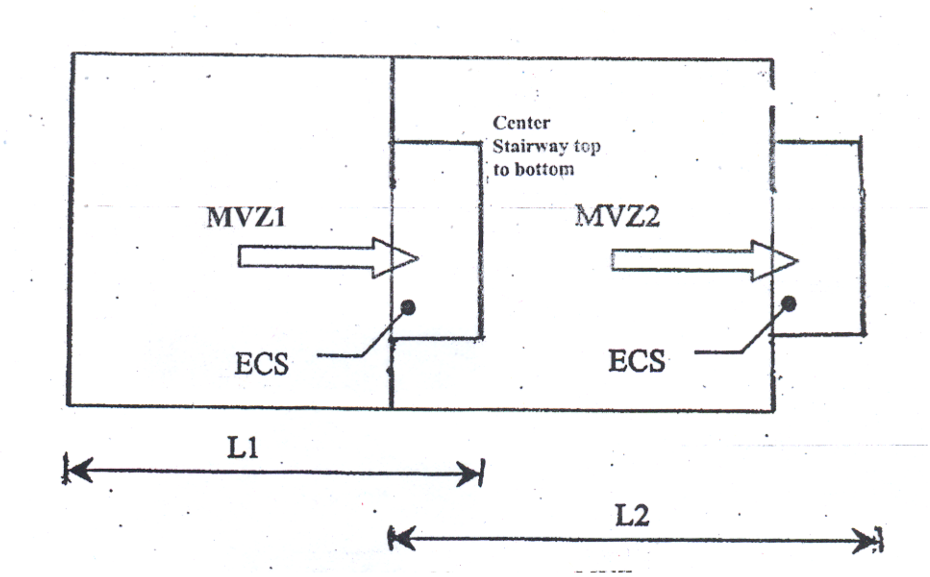

Fig.3.2.2.1 : ECS serves one MVZ

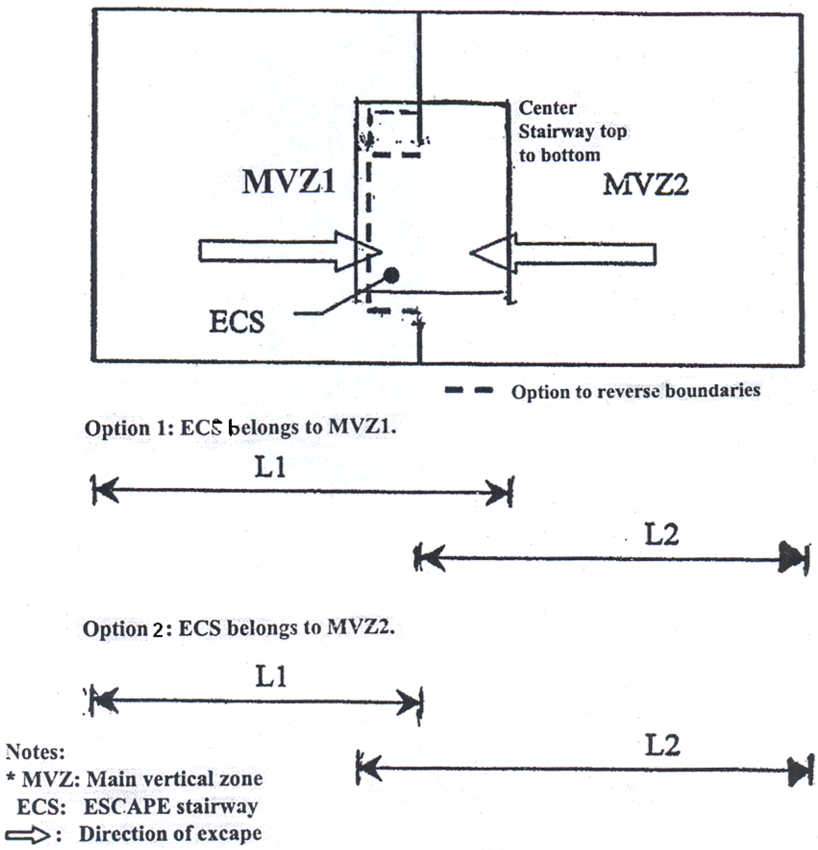

Fig.3.2.2.2 : ECS serves two MVZ's

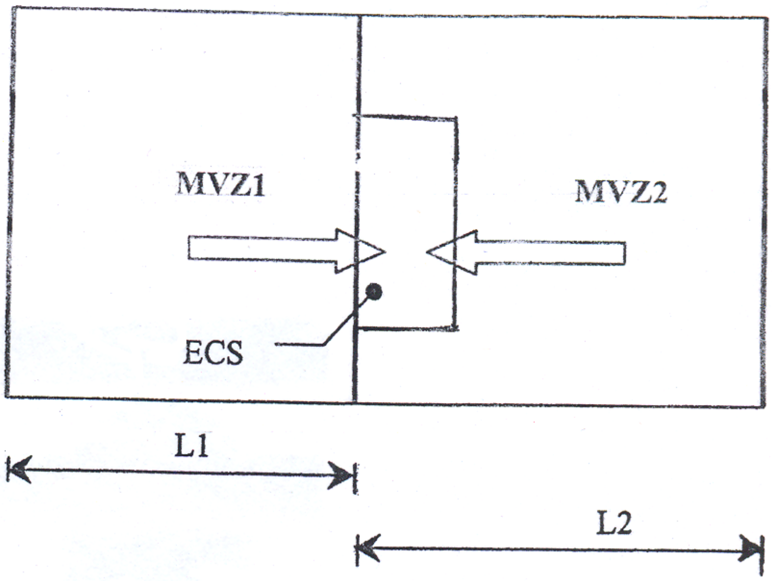

Fig.3.2.2.3 : ECS serves two MVZ's (ECS belongs to MVZ2)

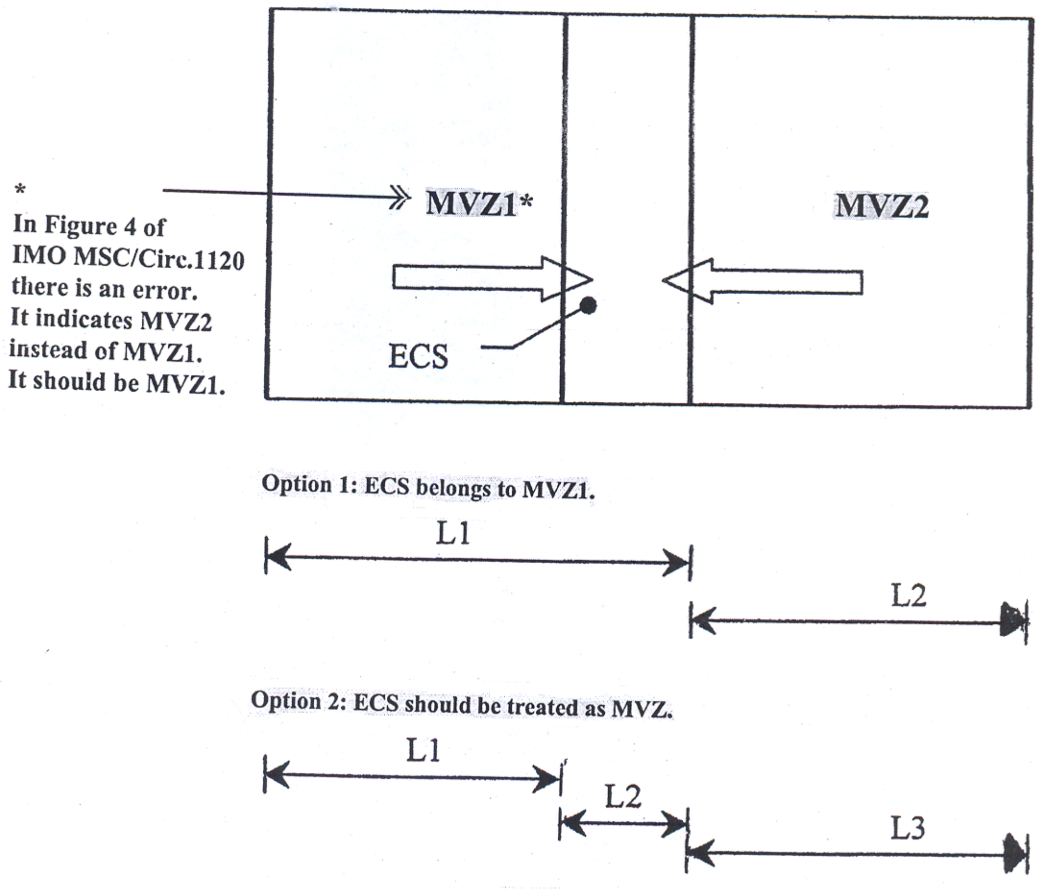

Fig.3.2.2.4 : ECS serves two MVZ's

3.2.2.1.3 Such bulkheads are to extend from deck to deck and to the shell or other boundaries.

3.2.2.1.4 Where a main vertical zone is subdivided by horizontal "A" class divisions into horizontal zones for the purpose of providing an appropriate barrier between a zone with sprinklers and a zone without sprinklers, the divisions are to extend between adjacent main vertical zone bulkheads and to the shell or exterior boundaries of the ship and are to be insulated in accordance with the fire insulation and integrity values given in Table 3.4.

3.2.2.1.5a) On ships designed for special purposes, such as automobile or railroad car ferries, where the provision of main vertical zone bulkheads would defeat the purpose for which the ship is intended, equivalent means for controlling and limiting a fire will be specially considered. Service spaces and ship stores are not to be located on ro-ro decks unless protected in accordance with the applicable requirements.

3.2.2.1.5b) However, in a ship with special category spaces, such spaces are to comply with the applicable provisions of Ch.7, Sec.3 and where such compliance would be inconsistent with other requirements for passenger ships specified in this part, the requirements of Ch.7, Sec.3 would apply.

3.2.2.2 *Bulkheads within a main vertical zone*

3.2.2.2.1 For ships carrying more than 36 passengers, bulkheads which are not required to be "A" class divisions are to be at least "B" class or "C" class divisions as prescribed in the tables in 3.2.2.3.

3.2.2.2.2 For ships carrying not more than 36 passengers, bulkheads within accommodation and service spaces which are not required to be "A" class divisions are to be at least "B" class or "C" class divisions as prescribed in the tables in 3.2.2.4. In addition, corridor bulkheads, where not required to be "A" class are to be "B" class divisions which are to extend from deck to deck except:

.1 when continuous "B" class ceilings or linings are fitted on both sides of the bulkhead, the portion of the bulkhead behind the continuous ceiling or lining is to be of material which, in thickness and composition, is acceptable in the construction of "B" class divisions, but which will be required to meet "B" class integrity standards only in so far as is reasonable and practicable; and

.2 in the case of a ship protected by an automatic sprinkler system complying with the provisions of the Fire Safety Systems Code (Chapter 8), the corridor bulkheads may terminate at a ceiling in the corridor provided such bulkheads and ceilings are of "B" class standard in compliance with 3.2.2.4. All doors and frames in such bulkheads are to be of non-combustible materials and are to have the same fire integrity as the bulkhead in which they are fitted.

3.2.2.2.3 Bulkheads required to be "B" class divisions, except corridor bulkheads as prescribed in 3.2.2.2.2, are to extend from deck to deck and to the shell or other boundaries. However, where a continuous "B" class ceiling or lining is fitted on both sides of a bulkhead which is at least of the same fire resistance as the adjoining bulkhead, the bulkhead may terminate at the continuous ceiling or lining. If an air gap between cabins results in an opening in the continuous B-15 ceiling, the bulkheads on the both sides of the air gap are to be of class B-15. MSC Circ.917 "Guidelines on fire safety construction in accommodation areas" may be referred for details of construction.

3.2.2.3 *Fire integrity of bulkheads and decks in ships carrying more than 36 passengers*

3.2.2.3.1 In addition to complying with the specific provisions for fire integrity of bulkheads and decks of passenger ships, the minimum fire integrity of all bulkheads and decks is to be as prescribed in Table 3.1 and Table 3.2. Where, due to any particular structural arrangements in the ship, difficulty is experienced in determining from the tables the minimum fire integrity value of any divisions, such values are to be determined to the satisfaction of IRS.

3.2.2.3.2 The following requirements are to govern application of the tables:

.1 Table 3.1 is to apply to bulkheads not bounding either main vertical zones or horizontal zones. Table 3.2 is to apply to decks not forming steps in main vertical zones nor bounding horizontal zones;

.2 For determining the appropriate fire integrity standards to be applied to boundaries between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (14) below. Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of this regulation, or where it is possible to assign two or more classifications to a space, it is to be treated as a space within the relevant category having the most stringent boundary requirements. Smaller, enclosed rooms within a space that have less than 30% communicating openings to that space are considered separate spaces. The fire integrity of the boundary bulkheads and decks of such smaller rooms is to be as prescribed in Table 3.1 and Table 3.2. The title of each category is intended to be typical rather than restrictive. The number in parentheses preceding each category refers to the applicable column or row in the tables.

(1) *Control stations*

- Spaces containing emergency sources of power and lighting.
- Wheelhouse and chartroom.
- Spaces containing the ship's radio equipment.
- Fire control stations.
- Control room for propulsion machinery when located outside the propulsion machinery space.
- Spaces containing centralized fire alarm equipment.
- Spaces containing centralized emergency public address system stations and equipment.

(2) *Stairways*

- Interior stairways, lifts, totally enclosed emergency escape trunks, and escalators (other than those wholly contained within the machinery spaces) for passengers and crew and enclosures thereto.
- In this connection a stairway which is enclosed at only one level is to be regarded as part of the space from which it is not separated by a fire door.

(3) *Corridors*

- Passenger and crew corridors and lobbies.

(4) *Evacuation stations and external escape routes*

- Survival craft stowage area.
- Open deck spaces and enclosed promenades forming lifeboat and liferaft embarkation and lowering stations.
- Assembly stations, internal and external.

- External stairs and open decks used for escape routes.
- The ship's side to the waterline in the lightest seagoing condition, superstructure and deckhouse sides situated below and adjacent to the liferaft and evacuation slide embarkation areas.

(5) *Open deck spaces*

- Open deck spaces and enclosed promenades clear of lifeboat and liferaft embarkation and lowering stations. To be considered in this category, enclosed promenades are to have no significant fire risk, meaning that furnishings are to be restricted to deck furniture. In addition, such spaces are to be naturally ventilated by permanent openings.
- Air spaces (the space outside superstructures and deckhouses).

(6) *Accommodation spaces of minor fire risk*

- Cabins containing furniture and furnishings of restricted fire risk.
- Offices and dispensaries containing furniture and furnishings of restricted fire risk.
- Public spaces containing furniture and furnishings of restricted fire risk and having a deck area of less than 50 [m^2].

(7) *Accommodation spaces of moderate fire risk*

- Spaces as in category (6) above but containing furniture and furnishings of other than restricted fire risk.
- Public spaces containing furniture and furnishings of restricted fire risk and having a deck area of 50 [m^2] or more.
- Isolated lockers and small store-rooms in accommodation spaces having areas less than 4 [m^2] (in which flammable liquids are not stowed).
- Motion picture projection and film stowage rooms. Diet kitchens (containing no open flame).
- Cleaning gear lockers (in which flammable liquids are not stowed).
- Laboratories (in which flammable liquids are not stowed).
- Pharmacies.
- Small drying rooms (having a deck area of 4 [m^2] or less).
- Specie rooms.
- Operating rooms.

(8) *Accommodation spaces of greater fire risk*

- Public spaces containing furniture and furnishings of other than restricted fire risk and having a deck area of 50 [m^2] or more.
- Barber shops and beauty parlours.
- Saunas.

(9) *Sanitary and similar spaces*

- Communal sanitary facilities, showers, baths, water closets, etc.
- Small laundry rooms.
- Indoor swimming pool area.
- Isolated pantries containing no cooking appliances in accommodation spaces.
- Private sanitary facilities are to be considered a portion of the space in which they are located.

(10) *Tanks, voids and auxiliary machinery spaces having little or no fire risk*

- Water tanks forming part of the ship's structure.
- Voids and cofferdams.
- Auxiliary machinery spaces which do not contain machinery having a pressure lubrication system and where storage of combustibles is prohibited, such as:
  - ventilation and air-conditioning rooms;
  - windlass room;
  - steering gear room;
  - stabilizer equipment room;
  - electrical propulsion motor room;
  - rooms containing section switchboards and purely electrical equipment other than oil-filled electrical transformers (above 10 kVA);
  - shaft alleys and pipe tunnels;
  - spaces for pumps and refrigeration machinery (not handling or using flammable liquids).
- Closed trunks serving the spaces listed above.
- Other closed trunks such as pipe and cable trunks.

(11) *Auxiliary machinery spaces, cargo spaces, cargo and other oil tanks and other similar spaces of moderate fire risk*

- Cargo oil tanks.
- Cargo holds, trunkways and hatchways.
- Refrigerated chambers.

- Oil fuel tanks (where installed in a separate space with no machinery).
- Shaft alleys and pipe tunnels allowing storage of combustibles.
- Auxiliary machinery spaces as in category (10) which contain machinery having a pressure lubrication system or where storage of combustibles is permitted.
- Oil fuel filling stations.
- Spaces containing oil-filled electrical transformers (above 10 kVA).
- Spaces containing turbine and reciprocating steam engine driven auxiliary generators and small internal combustion engines of power output up to 110 kW driving generators, sprinkler, drencher or fire pumps, bilge pumps, etc.
- Closed trunks serving the spaces listed above.

(12) *Machinery spaces and main galleys*

- Main propulsion machinery rooms (other than electric propulsion motor rooms) and boiler rooms.
- Auxiliary machinery spaces other than those in categories (10) and (11) which contain internal combustion machinery or other oil-burning, heating or pumping units.
- Main galleys and annexes.
- Trunks and casings to the spaces listed above.

(13) *Store-rooms, workshops, pantries, etc*.

- Main pantries not annexed to galleys.
- Main laundry.
- Large drying rooms (having a deck area of more than 4 [m^2]).
- Miscellaneous stores.
- Mail and baggage rooms.
- Garbage rooms.
- Workshops (not part of machinery spaces, galleys, etc.).
- Lockers and store-rooms having areas greater than 4 [m^2], other than those spaces that have provisions for the storage of flammable liquids.

(14) *Other spaces in which flammable liquids are stowed*

- Paint lockers.
- Store-rooms containing flammable liquids (including dyes, medicines, etc.).
- Laboratories (in which flammable liquids are stowed);

.3 Where a single value is shown for the fire integrity of a boundary between two spaces, that value will apply in all cases;

.4 Notwithstanding the provision of a 3.2.2.2 there are no special requirements for material or integrity of boundaries where only a dash appears in the tables; and

.5 In respect of category (5) spaces the insulation values in Table 3.1 apply to ends of deckhouses and superstructures, and the insulation values in Table 3.2 apply to weather decks. In no case will the requirements of category (5) of Table 3.1 or Table 3.2 necessitate enclosure of spaces which need not be enclosed.

IR.6 Distribution boards may be located behind panels/linings within accommodation spaces including stairway enclosures, without the need to categorize the space. However, this space is not to be used for any other storage purpose.

If distribution boards are located in an identifiable space having a deck area of less than 4 [m^2], this space may be categorized as (7).

(Note : Category (7) applies to 'Accommodation spaces of moderate fire risk').

3.2.2.3.3 Continuous "B" class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing wholly or in part, to the required insulation and integrity of a division.

3.2.2.3.4 *Construction and arrangement of saunas*

.1 The perimeter of the sauna is to be of "A" class boundaries and may include changing rooms, showers and toilets. The sauna is to be insulated to A-60 standard against other spaces except those inside of the perimeter and spaces of categories (5), (9) and (10).

.2 Bathrooms with direct access to saunas may be considered as part of them. In such cases, the door between sauna and the bathroom need not comply with fire safety requirements.

.3 The traditional wooden lining on the bulkheads and ceiling are permitted in the sauna. The ceiling above the oven is to be lined with a non-combustible plate with an air gap of at least 30 [mm]. The distance from the hot surfaces to combustible materials is to be atleast 500 [mm] or the combustible materials are to be protected (e.g. non-combustible plate with an air gap of at least 30 [mm]).

.4 The traditional wooden benches are permitted to be used in the sauna.

.5 The sauna door is to open outwards by pushing.

.6 Electrically heated ovens are to be provided with a timer.

3.2.2.4 *Fire integrity of bulkheads and decks in ships carrying not more than 36 passengers*

3.2.2.4.1 In addition to complying with the specific provisions for fire integrity of bulkheads and decks of passenger ships, the minimum fire integrity of bulkheads and decks are to be as prescribed in Table 3.3 and Table 3.4.

3.2.2.4.2 The following requirements govern application of the tables:

.1 Table 3.3 and Table 3.4 are to apply respectively to the bulkheads and decks separating adjacent spaces;

.2 For determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (11) below. Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of this regulation, or where it is possible to assign two or more classifications to a space, it is to be treated as a space within the relevant category having the most stringent boundary requirements. Smaller, enclosed rooms within a space that have less than 30 % communicating openings to that space are considered separate spaces. The fire integrity of the boundary bulkheads and decks of such smaller rooms are to be as prescribed in Table 3.3 and Table 3.4. The title of each category is intended to be typical rather than restrictive. The number in parentheses preceding each category refers to the applicable column or row in the tables.

Table 3.1 : Bulkheads not bounding either main vertical zones or horizontal zones (Ships with > 36 passengers)

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Control stations	(1)	B-0[a]	A-0	A-0	A-0	A-0	A-60	A-60	A-60	A-0	A-0	A-60	A-60	A-60	A-60
Stairways	(2)		A-0[a]	A-0	A-0	A-0	A-0	A-15	A-15	A-0[c]	A-0	A-15	A-30	A-15	A-30
Corridors	(3)			B-15	A-60	A-0	B-15	B-15	B-15	B-15	A-0	A-15	A-30	A-0	A-30
Evacuation stations and external escape routes	(4)					A-0	A-60[b,d]	A-60[b,d]	A-60[b,d]	A-0[d]	A-0	A-60[b]	A-60[b]	A-60[b]	A-60[b]
Open deck spaces	(5)						A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of minor fire risk	(6)						B-0	B-0	B-0	C	A-0	A-0	A-30	A-0	A-30
Accommodation spaces of moderate fire risk	(7)							B-0	B-0	C	A-0	A-15	A-60	A-15	A-60
Accommodation spaces of greater fire risk	(8)								B-0	C	A-0	A-30	A-60	A-15	A-60
Sanitary and similar spaces	(9)									C	A-0	A-0	A-0	A-0	A-0
Tanks, voids and auxiliary machinery spaces having little or no fire risk	(10)										A-0[a]	A-0	A-0	A-0	A-0
Auxiliary machinery spaces, cargo spaces, cargo and other oil tanks and other similar spaces of moderate fire risk	(11)											A-0[a]	A-0	A-0	A-15
Machinery spaces and main galleys	(12)												A-0[a]	A-0	A-60
Store-rooms, workshops, pantries, etc.	(13)													A-0[a]	A-0
Other spaces in which flammable liquids are stowed	(14)														A-30

See notes following Table 3.2.

Table 3.2 : Decks not forming steps in main vertical zones nor bounding horizontal zones (Ships with > 36 passengers)

Space		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Control stations	(1)	A-30	A-30	A-15	A-0	A-0	A-0	A-15	A-30	A-0	A-0	A-0	A-60	A-0	A-60
Stairways	(2)	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-30	A-0	A-30
Corridors	(3)	A-15	A-0	A-0[a]	A-60	A-0	A-0	A-15	A-15	A-0	A-0	A-0	A-30	A-0	A-30
Evacuation stations and external escape routes	(4)	A-0	A-0	A-0	A-0	-	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Open deck spaces	(5)	A-0	A-0	A-0	A-0	-	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of minor fire risk	(6)	A-60	A-15	A-0	A-60	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of moderate fire risk	(7)	A-60	A-15	A-15	A-60	A-0	A-0	A-15	A-15	A-0	A-0	A-0	A-0	A-0	A-0
Accommodation spaces of greater fire risk	(8)	A-60	A-15	A-15	A-60	A-0	A-15	A-15	A-30	A-0	A-0	A-0	A-0	A-0	A-0
Sanitary and similar spaces	(9)	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0
Tanks, voids and auxiliary machinery spaces having little or no fire risk	(10)	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0[a]	A-0	A-0	A-0	A-0
Auxiliary machinery spaces, cargo spaces, cargo and other oil tanks and other similar spaces of moderate fire risk	(11)	A-60	A-60	A-60	A-60	A-0	A-0	A-15	A-30	A-0	A-0	A-0[a]	A-0	A-0	A-30
Machinery spaces and main galleys	(12)	A-60	A-60	A-60	A-60	A-0	A-60	A-60	A-60	A-0	A-0	A-30	A-30[a]	A-0	A-60
Store-rooms, workshops, pantries, etc.	(13)	A-60	A-30	A-15	A-60	A-0	A-15	A-30	A-30	A-0	A-0	A-0	A-0	A-0	A-0
Other spaces in which flammable liquids are stowed	(14)	A-60	A-60	A-60	A-60	A-0	A-30	A-60	A-60	A-0	A-0	A-0	A-0	A-0	A-0

Note: To be applied to Table 3.1 and Table 3.2.

a Where adjacent spaces are in the same numerical category and superscript "a" appears a bulkhead or deck between such spaces need not be fitted if deemed unnecessary by IRS. For example, in category (12) a bulkhead will not be required between a galley and its annexed pantries provided the pantry bulkhead and decks maintain the integrity of the galley boundaries. A bulkhead is, however, required between a galley and machinery space even though both spaces are in category (12).

b The ship's side, to the waterline in the lightest seagoing condition, superstructure and deckhouse sides situated below and adjacent to liferafts and evacuation slides may be reduced to "A-30".

c Where public toilets are installed completely within the stairway enclosure, the public toilet bulkhead within the stairway enclosure can be of "B" class integrity.

d Where spaces of categories (6), (7), (8) and (9) are located completely within the outer perimeter of the assembly station, the bulkheads of these spaces are allowed to be of "B-0" class integrity. Control positions for audio, video and light installations may be considered as part of the assembly station.

(1) *Control stations*

- Spaces containing emergency sources of power and lighting.
- Wheelhouse and chartroom.
- Spaces containing the ship's radio equipment.
- Fire control stations.
- Control room for propulsion machinery when located outside the machinery space.
- Spaces containing centralized fire alarm equipment.

(2) *Corridors*

- Passenger and crew corridors and lobbies.

(3) *Accommodation spaces*

- Spaces as defined in Ch.1, 3.1 but excluding corridors.

(4) *Stairways*

- Interior stairways, lifts, totally enclosed emergency escape trunks, and escalators (other than those wholly contained within the machinery spaces) and enclosures thereto.
- In this connection, a stairway which is enclosed only at one level is to be regarded as part of the space from which it is not separated by a fire door.

(5) *Service spaces (low risk)*

- Lockers and store-rooms not having provisions for the storage of flammable liquids and having areas less than 4 [m^2] and drying rooms and laundries.

(6) *Machinery spaces of category A*

- Spaces as defined in Ch.1, 3.31.

(7) *Other machinery spaces*

- Electrical equipment rooms (auto-telephone exchange, air-conditioning duct spaces).
- Spaces as defined in Chapter 1, 3.30 excluding machinery spaces of category A.

(8) *Cargo spaces*

- All spaces used for cargo (including cargo oil tanks) and trunkways and hatchways to such spaces, other than special category spaces.

(9) *Service spaces (high risk)*

- Galleys, pantries containing cooking appliances, paint and lamp rooms, lockers and store-rooms having areas of 4 [m^2] or more, spaces for the storage of flammable liquids, saunas and workshops other than those forming part of the machinery spaces.

(10) *Open decks*

- Open deck spaces and enclosed promenades having little or no fire risk. Enclosed promenades are to have no significant fire risk, meaning that furnishing are to be restricted to deck furniture. In addition, such spaces are to be naturally ventilated by permanent openings. Air spaces (the space outside superstructures and deckhouses).

(11) *Special category and ro-ro spaces*

- Spaces as defined in Ch.1, 3.41 and 3.46.

IR.2 For location of distribution boards in accommodation spaces, refer to IR.6, 3.2.2.3.2 of this chapter.

.3 In determining the applicable fire integrity standard of a boundary between two spaces within a main vertical zone or horizontal zone which is not protected by an automatic sprinkler system complying with the provisions of the Fire Safety Systems Code (Chapter 8) or between such zones neither of which is so protected, the higher of the two values given in the tables are to apply; and

.4 In determining the applicable fire integrity standard of a boundary between two spaces within a main vertical zone or horizontal zone which is protected by an automatic sprinkler system complying with the provisions of the Fire Safety Systems Code (Chapter 8) or between such zones both of which are so protected, the lesser of the two values given in the tables is to apply. Where a zone with sprinklers and a zone without sprinklers meet within accommodation and service spaces, the higher of the two values given in the tables is to apply to the division between the zones.

3.2.2.4.3 Continuous "B" class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing, wholly or in part, to the required insulation and integrity of a division.

3.2.2.4.4 External boundaries which are required in 5.2 to be of steel or other equivalent material may be pierced for the fitting of windows and sidescuttles provided that there is no requirement for such boundaries of passenger ships to have "A" class integrity. Similarly, in such boundaries which are not required to have "A" class integrity, doors may be constructed of materials which are to the satisfaction of IRS.

3.2.2.4.5 Saunas are to comply with 3.2.2.3.4.

3.2.2.5 *Protection of stairways and lifts in accommodation area*

3.2.2.5.1 Stairways are to be within enclosures formed of "A" class divisions, with positive means of closure at all openings, except that:

.1 a stairway connecting only two decks need not be enclosed, provided the integrity of the deck is maintained by proper bulkheads or self-closing doors in one 'tween-deck space. When a stairway is closed in one 'tween-deck space, the stairway enclosure is to be protected in accordance with the tables for decks in 3.2.2.3 or 3.2.2.4; and

.2 stairways may be fitted in the open in a public space, provided they lie wholly within the public space.

3.2.2.5.2 Lift trunks are to be so fitted as to prevent the passage of smoke and flame from one ‘tween-deck to another and are to be provided with means of closing so as to permit the control of draught and smoke. Machinery for lifts located within stairway enclosures are to be arranged in a separate room, surrounded by steel boundaries, except that small passages for lift cables are permitted. Lifts which open into spaces other than corridors, public spaces, special category spaces, stairways and external areas are not to open into stairways included in the means of escape.

3.2.2.6 *Arrangement of cabin balconies*

On passenger ships constructed on or after 1 July 2008, non-load bearing partial bulkheads which separate adjacent cabin balconies are to be capable of being opened by the crew from each side for the purpose of fighting fires.

3.2.2.7 Protection of atriums

3.2.2.7.1 Atriums are to be within enclosures formed of “A” class divisions having a fire rating determined in accordance with Tables 3.2 and 3.4, as applicable.

3.2.2.7.2 Decks separating spaces within atriums are to have a fire rating determined in accordance with Tables 3.2 and 3.4, as applicable.

Table 3.3 : Fire integrity of bulkheads separating adjacent spaces
(Ships with ≤ 36 passengers)

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations	(1)	A-0 [c]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*	A-60
Corridors	(2)		C[e]	B-0[e]	A-0[a] B-0[e]	B-0[e]	A-60	A-0	A-0	A-15 A-0[d]	*	A-30[g]
Accommo-dation spaces	(3)			C[e]	A-0[a] B-0[e]	B-0[e]	A-60	A-0	A-0	A-15 A-0[d]	*	A-30 A-0[d]
Stairways	(4)				A-0[a] B-0[e]	A-0[a] B-0[e]	A-60	A-0	A-0	A-15 A-0[d]	*	A-30[g]
Service spaces (low risk)	(5)					C[e]	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A	(6)						*	A-0	A-0	A-60	*	A-60
Other machinery spaces	(7)							A-0[b]	A-0	A-0	*	A-0
Cargo spaces	(8)								*	A-0	*	A-0
Service spaces (high risk)	(9)									A-0[b]	*	A-30
Open decks	(10)											A-0
Special category and ro-ro spaces [g]	(11)											A-30[g]

Table 3.4 : Fire integrity of decks separating adjacent spaces
(Ships with ≤ 36 passengers)

-- Space above --

Space below		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations	(1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0	*	A-60[g]
Corridors	(2)	A-0	*	*	A-0	*	A-60	A-0	A-0	A-0	*	A-30[g]
Accommo-dation spaces	(3)	A-60	A-0	*	A-0	*	A-60	A-0	A-0	A-0	*	A-30 A-0[d]
Stairways	(4)	A-0	A-0	A-0	*	A-0	A-60	A-0	A-0	A-0	*	A-30[g]
Service spaces (low risk)	(5)	A-15	A-0	A-0	A-0	*	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A	(6)	A-60	A-60	A-60	A-60	A-60	*	A-60[f]	A-30	A-60	*	A-60
Other machinery spaces	(7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*	A-0
Cargo spaces	(8)	A-60	A-0	A-0	A-0	A-0	A-0	A-0	*	A-0	*	A-0
Service spaces (high risk)	(9)	A-60	A-30 A-0[d]	A-30 A-0[d]	A-30 A-0[d]	A-0	A-60	A-0	A-0	A-0	*	A-30
Open decks	(10)	*	*	*	*	*	*	*	*	*	-	A-0
Special category and ro-ro spaces [g]	(11)	A-60	A-30[g]	A-30 A-0[d]	A-30[g]	A-0	A-60[g]	A-0	A-0	A-30	A-0	A-30[g]

Notes: To be applied to both Table 3.3 and Table 3.4 as appropriate.

a For clarification as to which applies, see 3.2.2.2 and 3.2.2.5.

b Where spaces are of the same numerical category and superscript b appears, a bulkhead or deck of the rating shown in the tables is only required when the adjacent spaces are for a different purpose, (e.g. in category (9)). A galley next to a galley does not require a bulkhead but a galley next to a paint room requires an "A-0" bulkhead.

c Bulkhead separating the wheelhouse and chartroom from each other may have a "B-0" rating. No fire rating is required for those partitions separating the navigation bridge and the safety centre when the latter is within the navigation bridge

d See 3.2.2.4.2.3 and 3.2.2.4.2.4.

e For the application of 3.2.2.1.1b), "B-0" and "C", where appearing in Table 3.3, is to be read as "A-0".

f Fire insulation need not be fitted if the machinery space in category (7), in the opinion of IRS, has little or no fire risk.

g Ships constructed before 01 July 2014 are to comply, as a minimum, with the previous requirements applicable at the time the ship was constructed, as specified in Chapter 1, 1.3.

* Where an asterisk appears in the tables, the division is required to be of steel or other equivalent material, but is not required to be of "A" class standard. However, where a deck, except in a category (10) space, is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be made tight to prevent the passage of flame and smoke. Divisions between control stations (emergency generators) and open decks may have air intake openings without means for closure, unless a fixed gas fire-fighting system is fitted.

For the application of 3.2.2.1.1b), an asterisk, where appearing in Table 3.4, except for categories (8) and (10), is to be read as “A-0”.

3.2.3 Cargo ships except tankers

3.2.3.1 *Methods of protection in accommodation area*

3.2.3.1.1 One of the following methods of protection is to be adopted in accommodation and service spaces and control stations:

.1 **Method IC**

The construction of internal divisional bulkheads of non-combustible "B" or "C" class divisions generally without the installation of an automatic sprinkler, fire detection and fire alarm system in the accommodation and service spaces, except as required by 1.5.5.1; or

.2 **Method IIC**

The fitting of an automatic sprinkler, fire detection and fire alarm system as required by 1.5.5.2 for the detection and extinction of fire in all spaces in which fire might be expected to originate, generally with no restriction on the type of internal divisional bulkheads; or

.3 **Method IIIC**

The fitting of a fixed fire detection and fire alarm system as required by 1.5.5.3, in spaces in which a fire might be expected to originate, generally with no restriction on the type of internal divisional bulkheads, except that in no case must the area of any accommodation space or spaces bounded by an "A" or "B" class division exceed 50 [m^2]. However, increasing this area for public spaces will be specially considered.

IR 3.2.3.1 For fire protection materials refer Fig.3.1 and Table 3.5b and Table 3.5c.

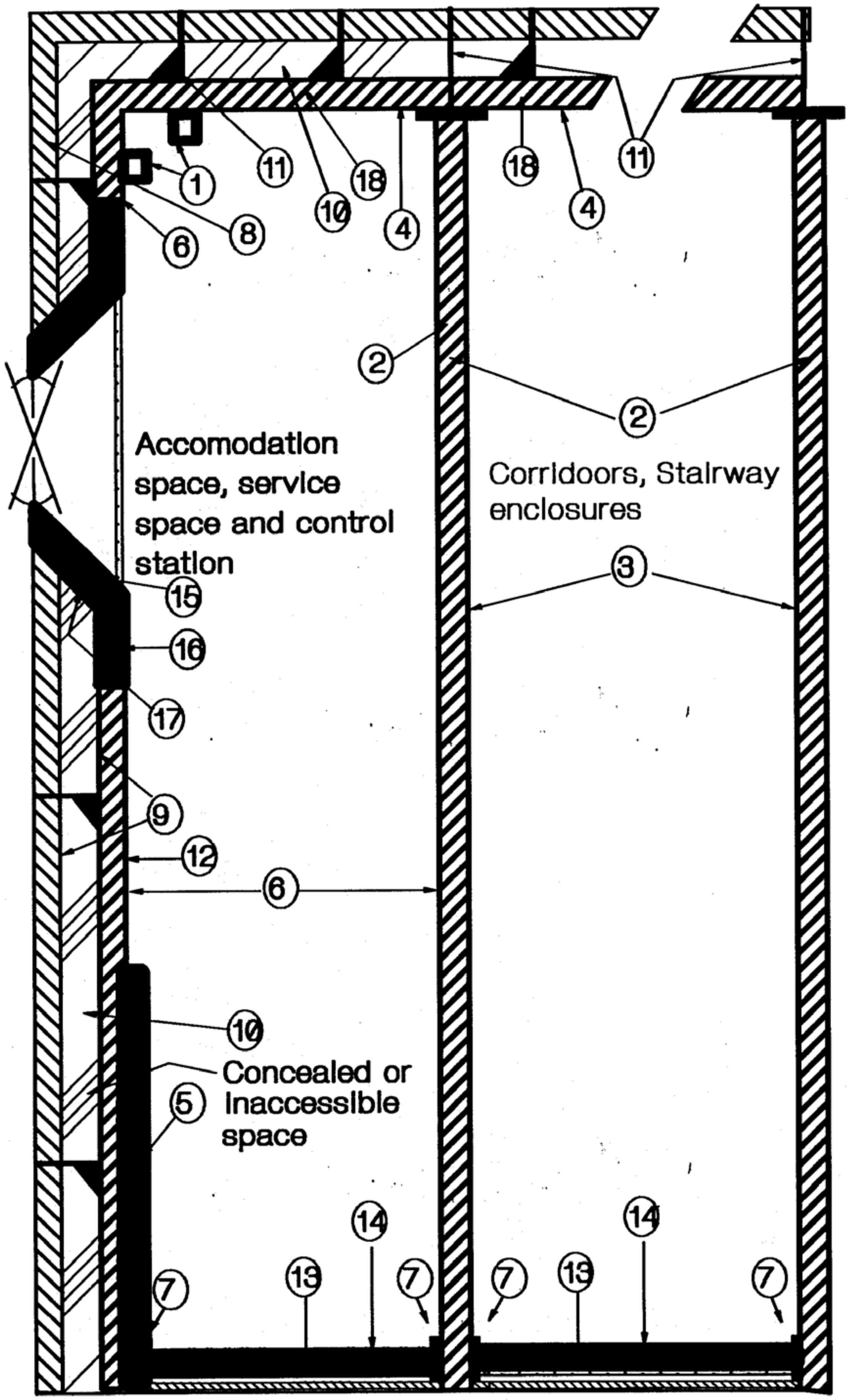

Fig. 3.1 : Fire protection materials

Table 3.5b : Method IC

		Requirements for Components						
		A Non-combu-stible material Ch.2, Cl. 2.3.1.2.2	**B Non-combu-stible material Ch.2, Cl. 2.3.1.1**	**C Low flame spread Ch.2, Cl. 2.3.2.4**	**D Equi-valent volume Ch.2, Cl. 2.3.2.3.a)**	**E Calorific value Ch.2, Cl. 2.3.2.2**	**F Smoke produc-tion Ch.2, Cl. 3.2.1; 3.3.1**	**G Not readily ignite Ch.2, Cl. 1.4.4.1**
1	Moulding				X			
2	Panel	X						
3	Painted surfaces or veneer or fabric or foils			X	X	X	X(2)	
4	Painted surfaces or veneer or fabric or foils			X	X	X	X(2)	
5	Decorative panel				X			
6	Painted surfaces or veneer or fabric or foils				X	X	X(2)	
7	Skirting board				X			
8	Insulation		X(1)					
9	Surfaces and paints in concealed or inaccessible spaces			X				
10	Draught stop	X						
11	Grounds and supports	X		X				
12	Lining	X						
13	Primary deck covering 1st layer						X	X
14	Floor finishing			X(3)			X	
15	Window box	X						
16	Window box surface			X	X	X	X	
17	Window box surface in concealed or inaccessible spaces			X				
18	Ceiling panel	X						

(1) Vapour barriers used on pipes for cold services (cold service means refrigeration system with temperatures below ambient air and sea water) may be of combustible materials provided that their surface has low flame spread characteristics.

(2) Applicable to paints, varnishes and other finishes. (Ch.2, Cl. 3.2.1).

(3) Only in corridors and stairway enclosures.

Table 3.5c : Method IIC - IIIC

		Requirements for Components						
		A Non-combustible material Ch.2, Cl. 2.3.1.2.2	B Non-combustible material Ch.2, Cl. 2.3.1.1	C Low flame spread Ch.2, Cl. 2.3.2.4	D Equiva-lent volume Ch.2, Cl. 2.3.2.3.a)	E Calorific value Ch.2, Cl. 2.3.2.2	F Smoke produc-tion Ch.2, Cl. 3.2.1; 3.3.1	G Not readily ignite Ch.2, Cl. 1.4.4.1
1	Moulding				X(3)			
2	Panel	X(4)						
3	Painted surfaces or veneer or fabric or foils			X	X	X	X(5)	
4	Painted surfaces or veneer or fabric or foils			X	X(3)	X(2)	X(5)	
5	Decorative panel				X(3)			
6	Painted surfaces or veneer or fabric or foils				X(3)	X(2)	X(5)	
7	Skirting board				X(3)			
8	Insulation		X(1)					
9	Surfaces and paints in concealed or inaccessible spaces			X				
10	Draught stop	X(4)						
11	Grounds and supports	X(4)		X				
12	Lining	X(4)						
13	Primary deck covering 1st layer						X	X
14	Floor finishing			X(6)			X	
15	Window box	X(4)						
16	Window box surface			X(3)	X(3)	X(2)	X	
17	Window box surface in concealed or inaccessible spaces			X				
18	Ceiling panel	X(4)						

(1) Vapour barriers used on pipes for cold services (cold service means refrigeration system with temperatures below ambient air and sea water) may be of combustible materials provided that their surface has low flame spread characteristics. (Ch.2, Cl.2.3.1.1).

(2) Where the material is fitted on non-combustible bulkheads, ceiling and lining in accommodation and service spaces. (Ch.2, Cl.2.3.2.2).

(3) To be applied to those accommodation and service spaces bounded by non-combustible bulkhead, ceiling and linings. (Ch.2, Cl.2.3.2.3.a).

(4) Only in corridors and stairway enclosures serving accommodation and service spaces and control stations. (Ch.2, Cl.2.3.1.2.2).

(5) Applicable to paints, varnishes and other finishes. (Ch.2, Cl. 3.2.1).

(6) Only in corridors and stairway enclosures.

3.2.3.1.2 The requirements for the use of non-combustible materials in the construction and insulation of boundary bulkheads of machinery spaces, control stations, service spaces, etc., and the protection of the above stairway enclosures and corridors will be common to all three methods outlined in 3.2.3.1.1.

3.2.3.2 *Bulkheads within accommodation area*

3.2.3.2.1 All bulkheads required to be 'B' class divisions are to extend from deck to deck and to the shell or other boundaries, unless continuous 'B' class ceilings and linings are fitted on both sides of the bulkhead in which case the bulkhead may terminate at the continuous ceiling or lining. MSC Circ.917 "Guidelines on fire safety construction in accommodation areas" may be referred for details of construction.

3.2.3.2.2 Method IC

Bulkheads not required by this or other regulations for cargo ships to be "A" or "B" class divisions, are to be of at least "C" class construction.

3.2.3.2.3 Method IIC

There are no restriction on the construction of bulkheads not required by this or other regulations for cargo ships to be "A" or "B" class divisions except in individual cases where "C" class bulkheads are required in accordance with Table 3.5a.

3.2.3.2.4 Method IIIC

There are no restriction on the construction of bulkheads not required for cargo ships to be "A" or "B" class divisions except that the area of any accommodation space or spaces bounded by a continuous "A" or "B" class division must in no case exceed 50 [m^2], except in individual cases where "C" class bulkheads are required in accordance with Table 3.5a. Consideration may be given to increasing this area for public spaces.

3.2.3.3 *Fire integrity of bulkheads and decks*

3.2.3.3.1 In addition to complying with the specific provisions for fire integrity of bulkheads and decks of cargo ships, the minimum fire integrity of bulkheads and decks are to be as prescribed in Table 3.5a and Table 3.6.

3.2.3.3.2 The following requirements are to govern application of the tables:

.1 Table 3.5a and Table 3.6 apply respectively to the bulkheads and decks separating adjacent spaces;

.2 For determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (11) below. Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of this section, or where it is possible to assign two or more classifications to a space, it is to be treated as a space within the relevant category having the most stringent boundary requirements. Smaller, enclosed rooms within a space that have less than 30% communicating openings to that space are considered separate spaces. The fire integrity of the boundary bulkheads and decks of such smaller rooms are to be as prescribed in Table 3.5a and Table 3.6. The title of each category is intended to be typical rather than restrictive. The number in parentheses preceding each category refers to the applicable column or row in the tables;

(1) *Control stations*

- Spaces containing emergency sources of power and lighting.
- Wheelhouse and chartroom.
- Spaces containing the ship’s radio equipment.
- Fire control stations.
- Control room for propulsion machinery when located outside the machinery space.
- Spaces containing centralized fire alarm equipment.

(2) *Corridors*

- Corridors and lobbies.

(3) *Accommodation spaces*

- Spaces as defined in Ch.1, 3.1, excluding corridors.

(4) *Stairways*

- Interior stairway, lifts, totally enclosed emergency escape trunks, and escalators (other than those wholly contained within the machinery spaces) and enclosures thereto.

- In this connection, a stairway which is enclosed only at one level is to be regarded as part of the space from which it is not separated by a fire door.

(5) *Service spaces (low risk)*

- Lockers and store-rooms not having provisions for the storage of flammable liquids and having areas less than 4 [m^2] and drying rooms and laundries.

(6) *Machinery spaces of category A*

- Spaces as defined in Ch.1, 3.31.

(7) *Other machinery spaces*

- Electrical equipment rooms (auto-telephone exchange, air-conditioning duct spaces).
- Spaces as defined in Ch.1, 3.30 excluding machinery spaces of category A.

(8) *Cargo spaces*

- All spaces used for cargo (including cargo oil tanks) and trunkways and hatchways to such spaces.

(9) *Service spaces (high risk)*

- Galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 [m^2] or more, spaces for the storage of flammable liquids, and workshops other than those forming part of the machinery spaces.

(10) *Open decks*

- Open deck spaces and enclosed promenades having little or no fire risk. To be considered in this category, enclosed promenades are to have no significant fire risk, meaning that furnishings are to be restricted to deck furniture. In addition, such spaces are to be naturally ventilated by permanent openings.

- Air spaces (the space outside superstructures and deckhouses).

(11) *Ro-ro and vehicle spaces*

- Ro-ro spaces as defined in Ch.1, 3.41.
- Vehicle spaces as defined in Ch.1, 3.49.

IR.2 For location of distribution boards in accommodation spaces, refer to IR.6, 3.2.2.3.2 of this chapter.

IR 3.2.3.3.2 Navigation equipment room (radar transmitter) and battery rooms are considered as category (1) Control stations for the purpose of this Rule.

Note 1 – Provision chambers are to be treated as store rooms.

2 – Refrigerated provision chambers are to be considered as category (9) service spaces if thermally insulated with combustible materials or category (5) service spaces if thermally insulated with non-combustible materials.

3.2.3.3.3 Continuous "B" class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing, wholly or in part, to the required insulation and integrity of a division.

3.2.3.3.4 External boundaries which are required in Ch.3, 5.2 to be of steel or other equivalent material may be pierced for the fitting of windows and sidescuttles provided that there is no requirement for such boundaries to have "A" class integrity. Similarly, in such boundaries which are not required to have "A" class integrity, doors may be constructed of materials which are to the satisfaction of IRS.

3.2.3.3.5 Saunas are to comply with 3.2.2.3.4.

3.2.3.4 *Protection of stairways and lift trunks in accommodation spaces, service spaces and control stations*

3.2.3.4.1 Stairways, which penetrate only a single deck are to be protected, at least at one level, by 'B-0' class division and self closing doors. Lifts penetrating a single deck only, are to be surrounded by 'A-0' class division with steel doors at both levels. Stairways and lift trunks penetrating more than a single deck are to be surrounded by at least 'A-0' class division and be protected by self closing doors at all levels.

IR 3.2.3.4.1 Dumb-waiters (food lifts) are to be regarded as lifts.

3.2.3.4.2 On ships having accommodation for 12 persons or less, where stairways penetrate more than a single deck and where there are at least two escape routes direct to the open deck at every accommodation level, the "A-0" requirements of 3.2.3.4.1 may be reduced to "B-0".

Table 3.5a : Fire integrity of bulkheads separating adjacent spaces (Cargo ships)

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations	(1)	A-0[e]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*	A-60
Corridors	(2)		C	B-0	B-0 A-0[f]	B-0	A-60	A-0	A-0	A-0	*	A-30
Accommodation spaces	(3)			C[a,b]	B-0 A-0[c]	B-0	A-60	A-0	A-0	A-0	*	A-30
Stairways	(4)				B-0 A-0[c]	B-0 A-0[c]	A-60	A-0	A-0	A-0	*	A-30
Service spaces (low risk)	(5)					C	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A	(6)						*	A-0	A-0[g]	A-60	*	A-60[f]
Other machinery spaces	(7)							A-0[d]	A-0	A-0	*	A-0
Cargo spaces	(8)								*	A-0	*	A-0
Service spaces (high risk)	(9)									A-0[d]	*	A-30
Open decks	(10)										-	A-0
Ro-ro and vehicle spaces	(11)											A-30[i]

Table 3.6 : Fire integrity of decks separating adjacent spaces (Cargo ships)

		-- Space above --										
Space below		**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
Control stations	(1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0	*	A-60
Corridors	(2)	A-0	*	*	A-0	*	A-60	A-0	A-0	A-0	*	A-30
Accommodation spaces	(3)	A-60	A-0	*	A-0	*	A-60	A-0	A-0	A-0	*	A-30
Stairways	(4)	A-0	A-0	A-0	*	A-0	A-60	A-0	A-0	A-0	*	A-30
Service spaces (low risk)	(5)	A-15	A-0	A-0	A-0	*	A-60	A-0	A-0	A-0	*	A-0
Machinery spaces of category A	(6)	A-60	A-60	A-60	A-60	A-60	*	A-60[i]	A-30	A-60	*	A-60
Other machinery spaces	(7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*	A-0
Cargo spaces	(8)	A-60	A-0	A-0	A-0	A-0	A-0	A-0	*	A-0	*	A-0
Service spaces (high risk)	(9)	A-60	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0[d]	*	A-30
Open decks	(10)	*	*	*	*	*	*	*	*	*	-	A-0[j]
Ro-ro and vehicle spaces	(11)	A-60	A-30	A-30	A-30	A-0	A-60	A-0	A-0	A-30	A-0[j]	A-30[j]

*Not*e: To be applied to Table 3.5a and Table 3.6 as appropriate.

a No special requirements are imposed upon bulkheads in methods IIC and IIIC fire protection.

b In case of method IIIC "B" class bulkheads of "B-0" rating are to be provided between spaces or groups of spaces of 50 [m^2] and over in area.

c For clarification as to which applies, see 3.2.3.2 and 3.2.3.4.

d Where spaces are of the same numerical category and superscript d appear, a bulkhead or deck of the rating shown in the tables is only required when the adjacent spaces are for a different purpose, e.g. in category (9), a galley next to a galley does not require a bulkhead but a galley next to a paint room requires an "A-0" bulkhead.

e Bulkheads separating the wheelhouse, chartroom and radio room from each other may have a "B-0" rating.

f An "A-0" rating may be used if no dangerous goods are intended to be carried or if such goods are stowed not less than 3 [m] horizontally from such a bulkhead.

g For cargo spaces in which dangerous goods are intended to be carried, Ch.7, 2.3.8 applies.

h Deleted.

i Fire insulation need not be fitted if the machinery in category (7) if, it has little or no fire risk.

j Ships constructed before 01 July 2014 are to comply, as a minimum, with the previous requirements applicable at the time the ship was constructed, as specified in Chapter 1, 1.3.

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* Where an asterisk appears in the tables, the division is required to be of steel or other equivalent material but is not required to be of "A" class standard. However, where a deck, except an open deck, is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be made tight to prevent the passage of flame and smoke. Divisions between control stations (emergency generators) and open decks may have air intake openings without means for closure, unless a fixed gas fire-fighting system is fitted.

3.2.4 Tankers

3.2.4.1 *Application*

For tankers, only method IC as defined in 3.2.3.1.1 is to be used.

3.2.4.2 *Fire integrity of bulkheads and decks*

3.2.4.2.1 In lieu of 3.2.3 and in addition to complying with the specific provisions for fire integrity of bulkheads and decks of tankers, the minimum fire integrity of bulkheads and decks is to be as prescribed in Table 3.7 and Table 3.8.

3.2.4.2.2 The following requirements govern application of the tables:

.1 Table 3.7 and Table 3.8 apply respectively to the bulkhead and decks separating adjacent spaces;

.2 For determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (10) below. Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of this regulation, or where it is possible to assign two or more classifications to a space, it is to be treated as a space within the relevant category having the most stringent boundary requirements. Smaller, enclosed areas within a space that have less than 30% communicating openings to that space are considered separate areas. The fire integrity of the boundary bulkheads and decks of such smaller spaces is to be as prescribed in Table 3.7 and Table 3.8. The title of each category is intended to be typical rather than restrictive. The number in parentheses preceding each category refers to the applicable column or row in the tables;

(1) *Control stations*

- Spaces containing emergency sources of power and lighting.

- Wheelhouse and chartroom.
- Spaces containing the ship's radio equipment.
- Fire control stations.
- Control room for propulsion machinery when located outside the machinery space.
- Spaces containing centralized fire alarm equipment.

(2) *Corridors*

- Corridors and lobbies.

(3) *Accommodation spaces*

- Spaces as defined in Ch.1, 3.1, excluding corridors.

(4) *Stairways*

- Interior stairways, lifts, totally enclosed emergency escape trunks, and escalators (other than those wholly contained within the machinery spaces) and enclosures thereto.
- In this connection, a stairway which is enclosed only at one level is to be regarded as part of the space from which it is not separated by a fire door.

(5) *Service spaces (low risk)*

- Lockers and store-rooms not having provisions for the storage of flammable liquids and having areas less than 4 [m^2] and drying rooms and laundries.

(6) *Machinery spaces of category A*

- Spaces as defined in Ch.1, 3.31.

(7) *Other machinery spaces*

- Electrical equipment rooms (auto-telephone exchange and air-conditioning duct spaces).\
- Spaces as defined in Ch.1, 3.30 excluding machinery spaces of category A.

(8) *Cargo pump-rooms*

- Spaces containing cargo pumps and entrances and trunks to such spaces.

(9) *Service spaces (high risk)*

- Galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 [m^2] or more, spaces for the storage of flammable liquids and workshops other than those forming part of the machinery spaces.

(10) *Open decks*

- Open deck spaces and enclosed promenades having little or no fire risk. To be considered in this category, enclosed promenades are to have no significant fire risk, meaning that furnishings are to be restricted to deck furniture. In addition, such spaces are to be naturally ventilated by permanent openings.
- Air spaces (the space outside superstructures and deckhouses).

IR.2 For location of distribution boards in accommodation spaces, refer to IR.6, 3.2.2.3.2 of this chapter.

IR 3.2.4.2.2 Navigation equipment room (radar transmitter) and battery rooms are considered as category (1) Control stations for the purpose of this Rule.

Note 1 – Provision chambers are to be treated as store rooms.

2 – Refrigerated provision chambers are to be considered as category (9) service spaces if thermally insulated with combustible materials or category (5) service spaces if thermally insulated with non-combustible materials.

3.2.4.2.3 Continuous "B" class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing, wholly or in part, to the required insulation and integrity of a division.

3.2.4.2.4 External boundaries which are required in Ch.3, 5.2 to be of steel or other equivalent material may be pierced for the fitting of windows and side scuttles provided that there is no requirement for such boundaries of tankers to have "A" class integrity. Similarly, in such boundaries which are not required to have "A" class integrity, doors may be constructed of materials which are to the satisfaction of IRS.

3.2.4.2.5 Exterior boundaries of superstructures and deckhouses enclosing accommodation and including any overhanging decks which support such accommodation, are to be constructed of steel and insulated to "A-60" standard for the whole of the portions which face the cargo area and on the outward sides for a distance of 3 [m] from the end boundary facing the cargo area. The distance of 3 [m] is to be measured horizontally and parallel to the middle line of the ship from the boundary which faces the cargo area at each deck level. In the case of the sides of those superstructures and deckhouses, such insulation is to be carried up to the underside of the deck of the navigation bridge. (also see IR3.2.4.2.5).

IR3.2.4.2.5 “A-60” standard insulation is to be provided for the portions which face the cargo area upto the underside of the navigation bridge deck.

3.2.4.2.6 Skylights to cargo pump-rooms are to be of steel and are not to contain any glass. These are to be capable of being closed from outside the pump-room.

3.2.4.2.7 Construction and arrangement of saunas are to comply with 3.2.2.3.4.

Table 3.7 : Fire integrity of bulkheads separating adjacent spaces (tankers)

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations	(1)	A-0[c]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*
Corridors	(2)		C	B-0	B-0 A-0[a]	B-0	A-60	A-0	A-60	A-0	*
Accommodation spaces	(3)			C	B-0 A-0[a]	B-0	A-60	A-0	A-60	A-0	*
Stairways	(4)				B-0 A-0[a]	B-0 A-0[a]	A-60	A-0	A-60	A-0	*
Service spaces (low risk)	(5)					C	A-60	A-0	A-60	A-0	*
Machinery spaces of category A	(6)						*	A-0	A-0[d]	A-60	*
Other machinery spaces	(7)							A-0[b]	A-0	A-0	*
Cargo pump-rooms	(8)								*	A-60	*
Service spaces (high risk)	(9)									A-0[b]	*
Open decks	(10)										-

Table 3.8 : Fire integrity of decks separating adjacent spaces (tankers)											
		-- Space above --									
Space below		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations	(1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	-	A-0	*
Corridors	(2)	A-0	*	*	A-0	*	A-60	A-0	-	A-0	*
Accommodation spaces	(3)	A-60	A-0	*	A-0	*	A-60	A-0	-	A-0	*
Stairways	(4)	A-0	A-0	A-0	*	A-0	A-60	A-0	-	A-0	*
Service spaces (low risk)	(5)	A-15	A-0	A-0	A-0	*	A-60	A-0	-	A-0	*
Machinery spaces of category A	(6)	A-60	A-60	A-60	A-60	A-60	*	A-60[e]	A-0	A-60	*
Other machinery spaces	(7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*
Cargo pump-rooms	(8)	-	-	-	-	-	A-0[d]	A-0	*	-	*
Service spaces (high risk)	(9)	A-60	A-0	A-0	A-0	A-0	A-60	A-0	-	A-0[b]	*
Open decks	(10)	*	*	*	*	*	*	*	*	*	-

*Note*s: To be applied to Table 3.7 and Table 3.8 as appropriate.

a For clarification as to which applies, see 3.2.3.2 and 3.2.3.4.

b Where spaces are of the same numerical category and superscript b appears, a bulkhead or deck of the rating shown in the tables is only required when the adjacent spaces are for a different purpose (e.g. in category (9)). A galley next to a galley does not require a bulkhead but a galley next to a paint room requires an "A-0" bulkhead.

c Bulkheads separating the wheelhouse, chartroom and radio room from each other may have a "B-0" rating.

d Bulkheads and decks between cargo pump-rooms and machinery spaces of category A may be penetrated by cargo pump shaft glands and similar gland penetrations, provided that gas tight seals with efficient lubrication or other means of ensuring the permanence of the gas seal are fitted in way of the bulkheads or deck.

e Where subscript 'e' appears in the Tables, fire insulation need not be fitted if the machinery space in Category (7) has little or no fire risk.

* Where an asterisk appears in the table, the division is required to be of steel or other equivalent material, but is not required to be of "A" class standard. However, where a deck, except an open deck, is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be made tight to prevent the passage of flame and smoke. Divisions between control stations (emergency generators) and open decks may have air intake openings without means for closure, unless a fixed gas fire-fighting system is fitted.

3.3 Penetration in fire-resisting divisions and prevention of heat transmission

3.3.1 Where "A" class divisions are penetrated, such penetrations are to be tested in accordance with the Fire Test Procedures Code, subject to the provisions of 3.4.1.1.5. In the case of ventilation ducts, 3.7.1.2 and 3.7.3.1 apply. However, where a pipe penetration is made of steel or equivalent material having a thickness of 3 [mm] or greater and a length of not less than 900 [mm] (preferably 450 [mm] on each side of the division), and no openings, testing is not required. Such penetrations are to be suitably insulated by extension of the insulation at the same degree of fire integrity of the division.

3.3.2 Where "B" class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements are to be made to ensure that the fire resistance is not impaired, subject to the provisions of 3.7.3.2. Pipes other than steel or copper that penetrate "B" class divisions are to be protected by either:

.1 a fire tested penetration device, suitable for the fire resistance of the division pierced and the type of pipe used; or

.2 a steel sleeve, having a thickness of not less than 1.8 [mm] and a length of not less than 900 [mm] for pipe diameters of 150 [mm] or more and not less than 600 [mm] for pipe diameters of less than 150 [mm] (preferably equally divided to each side of the division). The pipe is to be connected to the ends of the sleeve by flanges or couplings; or the clearance between the sleeve and the pipe is not to exceed 2.5 [mm]; or any clearance between pipe and sleeve is to be made tight by means of non-combustible or other suitable material.

3.3.3 Uninsulated metallic pipes penetrating "A" or "B" class divisions are to be of materials having a melting temperature which exceeds 950ºC for “A-0” and 850ºC for “B-0” class divisions.

3.3.4 In designing structural fire protection details, the risk of heat transmission at intersections and terminal points of required thermal barriers is to be considered. The insulation of a deck or bulkhead is to be carried past the penetration, intersection or terminal point for a distance of at least 450 [mm] in the case of steel and aluminium structures. If a space is divided with a deck or a bulkhead of "A" class standard having insulation of different values, the insulation with the higher value is to continue on the deck or bulkhead with the insulation of the lesser value for a distance of at least 450 [mm].

3.4 Protection of openings in fire resisting divisions

3.4.1 Openings in bulkheads and decks in passenger ships

3.4.1.1 *Openings in "A" class divisions*

3.4.1.1.1 Except for hatches between cargo, special category, store and baggage spaces, and between such spaces and weather decks, all openings are to be provided with permanently attached means of closing which are to be at least as effective for resisting fires as the divisions in which they are fitted.

3.4.1.1.2 The construction of doors and door frames in "A" class divisions, with the means of securing them when closed, is to provide resistance to fire as well as to the passage of smoke and flame equivalent to that of the bulkheads in which the doors are situated, this being determined in accordance with the Fire Test Procedures Code. Such doors and door frames are to be constructed of steel or other equivalent material. Doors approved without the sill being part of the frame, which are installed on or after 1 July 2010 are to be installed such that the gap under the door does not exceed 12 [mm]. A non-combustible sill is to be installed under the door such that floor coverings do not extend beneath the closed door.

3.4.1.1.3 Watertight doors need not be insulated.

3.4.1.1.4 It is to be possible for each door to be opened and closed from each side of the bulkhead by one person only.

3.4.1.1.5 Fire doors in main vertical zone bulkheads, galley boundaries and stairway enclosures other than power-operated watertight doors and those which are normally locked, are to satisfy the following requirements:

.1 the doors are to be self-closing and be capable of closing against an angle of inclination of up to 3.5° opposing closure;

.2 the approximate time of closure for hinged fire doors is to be not more than 40 seconds and no less than 10 seconds from the beginning of their movement with the ship in upright position. The approximate uniform rate of closure for sliding fire doors is to be of not more than 0.2 [m/s] and not less than 0.1 [m/s] with the ship in the upright position;

.3 the doors, except those for emergency escape trunks, are to be capable of remote release from the continuously manned central control station, either simultaneously or in groups and are to be capable of release also individually from a position at both sides of the door. Release switches are to have an on-off function to prevent automatic resetting of the system;

.4 use of hold-back hooks not subject to central control station release is prohibited;

.5 a door closed remotely from the central control station is to be capable of being re-opened at both sides of the door by local control. After such local opening the door is to close automatically again;

.6 indication is to be provided at the fire door indicator panel in the continuously manned central control station whether each of the remote-released doors are closed;

.7 the release mechanism is to be so designed that the door will automatically close in the event of disruption of the control system or central power supply;

.8 local power accumulators for power-operated doors are to be provided in the immediate vicinity of the doors to enable the doors to be operated after disruption of the control system or central power supply at least ten times (fully opened and closed) using the local controls;

.9 disruption of the control system or central power supply at one door is not to impair the safe functioning of the other doors;

.10 remote-released sliding or power-operated doors are to be equipped with an alarm that sounds for at least 5 seconds but no more than 10 seconds after the door is released from the central control station and before the door begins to move and continue sounding until the door is completely closed;

.11 a door designed to re-open upon contacting an object in its path is to re-open not more than 1 [m] from the point of contact;

.12 double-leaf doors equipped with a latch necessary for their fire integrity are to have a latch that is automatically activated by the operation of the doors when released by the control system;

.13 doors giving direct access to special category spaces which are power-operated and automatically closed need not be equipped with the alarms and remote- release mechanisms required in .3 and .10;

.14 the components of the local control system are to be accessible for maintenance and adjusting; and

.15 power-operated doors are to be provided with a control system of an approved type which is to be able to operate in case of fire, this being determined in accordance with the Fire Test Procedures Code. This system is to satisfy the following requirements:

i) the control system is to be able to operate the door at the temperature of at least 200°C for at least 60 minutes, served by the power supply;

ii) the power supply for all other doors not subject to fire is not to be impaired; and

iii) at temperatures exceeding 200°C the control system is to be automatically isolated from the power supply and is to be capable of keeping the door closed up to at least 945°C.

IR.16 indication signals for lift doors provided in accordance with .13 above are to meet the following:

i) the signal showing that "A" class lift doors are in the closed position is to be activated only when the order to close the main fire doors has been given by the continuously manned central control station;

ii) when there are several lifts giving access to the same stairway, the lift door indicators located in the continuously manned central control station are to be capable of indicating that all the lift doors giving access to the same landing are properly closed. This indication is to be shown on the panel; and

iii) when an order to close the main fire doors is given, the same order is also to stop the lifts from operating by sending them to pre-specified deck, to be determined on a case-by-case basis according to the ship's design. In addition, those inside the lift are to be able to order the lift doors open while those outside the lift are not to be able to do so.

3.4.1.1.6 In ships carrying not more than 36 passengers, where a space is protected by an automatic sprinkler fire detection and alarm system complying with the provisions the Fire Safety Systems Code or fitted with a continuous "B" class ceiling, openings in decks not forming steps in main vertical zones nor bounding horizontal zones are to be closed reasonably tight and such decks are to meet the "A" class integrity requirements in so far as is reasonable and practicable in the opinion of IRS.

3.4.1.1.7 The requirements for "A" class integrity of the outer boundaries of a ship do not apply to glass partitions, windows and sidescuttles, provided that there is no requirement for such boundaries to have "A" class integrity in 3.4.1.3.3. The requirements for "A" class integrity of the outer boundaries of the ship do not apply to exterior doors, except for those in superstructures and deckhouses facing lifesaving appliances, embarkation and external assembly station areas, external stairs and open decks used for escape routes. Stairway enclosure doors need not meet this requirement.

3.4.1.1.8 Except for watertight doors, weathertight doors (semi-watertight doors), doors leading to the open deck and doors which need to be reasonably gastight, all "A" class doors located in stairways, public spaces and main vertical zone bulkheads in escape routes are to be equipped with a self-closing hose port of material, construction and fire resistance which is equivalent to the door into which it is fitted, and is to be a 150 [mm] square clear opening with the door closed and is to be inset into the lower edge of the door, opposite the door hinges or, in the case of sliding doors, nearest the opening.

3.4.1.1.9 Where it is necessary that a ventilation duct passes through a main vertical zone division, a fail-safe automatic closing fire damper is to be fitted adjacent to the division. The damper is also to be capable of being manually closed from each side of the division. The operating position is to be readily accessible and be marked in red light-reflecting colour. The duct between the division and the damper is to be of steel or other equivalent material and, if necessary, insulated to comply with the requirements of 3.3.1. The damper is to be fitted on at least one side of the division with a visible indicator showing whether the damper is in the open position.

3.4.1.2 *Openings in "B" class divisions*

3.4.1.2.1 Doors and door frames in "B" class divisions and means of securing them is to provide a method of closure which will have resistance to fire equivalent to that of the divisions, this being determined in accordance with the Fire Test Procedure Code except that ventilation openings may be permitted in the lower portion of such doors. Where such opening is in or under a door the total net area of opening is not to exceed 0.05 [m^2]. Alternatively, a non-combustible air balance duct routed between the cabin and the corridor, and located below the sanitary unit is permitted where the cross-sectional area of the duct does not exceed 0.05 [m^2]. All ventilation openings are to be fitted with a grill made of non-combustible material. Doors are to be non-combustible. Doors approved without the sill being part of the frame, which are installed on or after 1 July 2010 are to be installed such that the gap under the door does not exceed 25 [mm].

IR3.4.1.2.1 Balancing openings or ducts between two enclosed spaces are prohibited except for openings as permitted by 3.4.1.2.1.

3.4.1.2.2 Cabin doors in "B" class divisions are to be of a self-closing type. Hold-back hooks are not permitted.

3.4.1.2.3 The requirements for 'B' class integrity of the outer boundaries of a ship are not to apply to glass partitions, windows and side scuttles. Similarly, the requirements for 'B' class integrity are not to apply to exterior doors in superstructures and deckhouses. For ships carrying not more than 36 passengers, the use of combustible materials in doors separating cabins from the individual interior sanitary spaces, such as showers, may be permitted.

3.4.1.2.4 In ships carrying not more than 36 passengers, where an automatic sprinkler system complying with the provisions of the Fire Safety Systems Code (Chapter 8) is fitted:

.1 openings in decks not forming steps in main vertical zones nor bounding horizontal zones are to be closed reasonably tight and such decks are to meet the "B" class integrity requirements in so far as is reasonable and practicable in the opinion of IRS; and

.2 openings in corridor bulkheads of "B" class materials are to be protected in accordance with the provisions of 3.2.2.2.

3.4.1.3 *Windows and sidescuttles*

3.4.1.3.1 Windows and sidescuttles in bulkheads within accommodation and service spaces and control stations other than those to which the provisions of 3.4.1.1.6 and of 3.4.1.2.3 apply, are to be so constructed as to preserve the integrity requirements of the type of bulkheads in which they are fitted, this being determined in accordance with the Fire Test Procedures Code.

3.4.1.3.2 Notwithstanding the requirements of Table 3.1 to Table 3.4, windows and sidescuttles in bulkheads separating accommodation and service spaces and control stations from weather are to be constructed with frames of steel or other suitable material. The glass is to be retained by a metal glazing bead or angle.

3.4.1.3.3 Windows facing life-saving appliances, embarkation and assembly stations, external stairs and open decks used for escape routes, and windows situated below liferaft and escape slide embarkation areas are to have fire integrity as required in Table 3.1. Where automatic dedicated sprinkler heads are provided for windows, "A-0" windows may be accepted as equivalent. To be considered under this paragraph, the sprinkler heads are either to be:

.1 dedicated heads located above the windows, and installed in addition to the conventional ceiling sprinklers; or

.2 conventional ceiling sprinkler heads arranged such that the window is protected by an average application rate of at least 5 l/m^2 and the additional window area is included in the calculation of the area of coverage; or

.3 water-mist nozzles that have been tested and approved based on the guidelines developed by IMO. [Refer to the revised guidelines for approval of sprinkler systems equivalent to that referred to in SOLAS regulation II-2/12 (Resolution A 800(19))].

Windows located in the ship's side below the lifeboat embarkation area are to have fire integrity at least equal to "A-0" class.

Also refer MSC Circ.917 "Guidelines on fire safety construction in accommodation".

3.4.2 Doors in fire-resisting divisions in cargo ships

3.4.2.1 The fire resistance of doors is to be equivalent to that of the division in which they are fitted, this being determined in accordance with the Fire Test Procedures Code. Doors approved as "A" class without the sill being part of the frame, which are installed on or after 1 July 2010 are to be installed such that the gap under the door does not exceed 12 [mm] and a non-combustible sill is to be installed under the door such that floor coverings do not extend beneath the closed door. Doors approved as "B" class without the sill being part of the frame, which are installed on or after 1 July 2010 are to be installed such that the gap under the door does not exceed 25 [mm]. Doors and door frames in "A" class divisions are to be constructed of steel. Doors in "B" class divisions are to be non-combustible. Doors fitted in boundary bulkheads of machinery spaces of category A are to be reasonably gastight and self-closing. Where method IC is adopted the use of combustible materials in doors separating cabins from individual interior sanitary accommodation such as showers may be permitted.

3.4.2.2 Doors required to be self closing are not to be fitted with hold back hooks. However, hold back arrangements fitted with remote release devices of the fail safe type may be utilized.

3.4.2.3 In corridor bulkheads ventilation openings may be permitted in and under the doors of cabins and public spaces. Ventilation openings are also permitted in "B" class doors leading to lavatories, offices, pantries, lockers and store rooms. Except as permitted below, the openings are to be provided only in the lower half of a door. Such opening in or under a door is not to have the total net area exceeding 0.05 [m^2]. Alternatively, a non-combustible air balance duct routed between the cabin and the corridor, and located below the sanitary unit is permitted where the cross-sectional area of the duct does not exceed 0.05 [m^2]. Ventilation openings, except those under the door, are to be fitted with a grille made of non-combustible material.

IR3.4.2.3 Balancing openings or ducts between two enclosed spaces are prohibited except for openings as permitted by 3.4.2.3.

3.4.2.4 Watertight doors need not be insulated.

3.5 Protection of openings in machinery spaces boundaries

3.5.1 Application

3.5.1.1 The provision of 3.5 is to apply to machinery spaces of category A and, where IRS considers it desirable, to other machinery spaces.

3.5.2 Protection of openings in machinery space boundaries

3.5.2.1 The number of skylights, doors, ventilators, openings in funnels to permit exhaust ventilation and other openings to machinery spaces are to be reduced to a minimum consistent with the needs of ventilation and the proper and safe working of the ship.

3.5.2.2 Skylights are to be of steel and are not to contain glass panels.

3.5.2.3 Means of control are to be provided for closing power-operated doors or actuating release mechanisms on doors other than power-operated watertight doors. The control is to be located outside the space concerned, where they will not be cut off in the event of fire in the space it serves.

3.5.2.4 In passenger ships, the means of control required in 3.5.2.3 are to be situated at one control position or grouped in as few positions as possible to the satisfaction of IRS. Such positions are to have safe access from the open deck.

3.5.2.5 In passenger ships, doors, other than power-operated watertight doors are to be so arranged that positive closure is assured in case of fire in the space by power-operated closing arrangements or by the provision of self-closing doors capable of closing against an inclination of 3.5° opposing closure, and having a fail-safe hook-back facilities provided with a remotely operated release device. Doors for emergency escape trunks need not be fitted with a fail-safe hold-back facility and a remotely operated release device.

3.5.2.6 Windows are not to be fitted in machinery space boundaries. Glass may be used in control rooms within the machinery spaces.

IR3.5.2.7 When access to any machinery space of category A is provided at a low level from an adjacent shaft tunnel, there must be provided in the shaft tunnel, near the watertight door, a light steel fire-screen door operable from both sides.

3.6 Protection of cargo space boundaries

3.6.1 In passenger ships carrying more than 36 passengers, the boundary bulkheads and decks of special category and ro-ro spaces are to be insulated to "A-60" class standard. However, where a category (5), (9) and (10) space, as defined in 3.2.2.3, is on one side of the division the standard may be reduced to "A-0". Where fuel oil tanks are below a special category space, the integrity of the deck between such spaces may be reduced to "A-0" standard.

3.6.2 In passenger ships, indicators are to be provided on the navigating bridge which will indicate when any fire door leading to or from the special category spaces is closed.

3.6.3 In tankers for the protection of cargo tanks carrying crude oil and petroleum products having a flash point not exceeding 60°C, materials readily rendered ineffective by heat are not to be used for valves, fittings, tank opening covers, cargo vent piping, and cargo piping so as to prevent the spread of fire to the cargo.

3.7 Ventilation systems

3.7.1 General

3.7.1.1 Ventilation ducts, including single and double wall ducts, are to be of steel or equivalent material except flexible bellows of short length not exceeding 600 [mm] used for connecting fans to the ducting in air-conditioning rooms. Unless expressly provided otherwise in paragraph 3.7.1.6, any other material used in the construction of ducts, including insulation, are also to be non-combustible. However, short ducts, not generally exceeding 2 [m] in length and with a free cross-sectional area* not exceeding 0.02 [m^2], need not be of steel or equivalent material, subject to the following conditions:

(* The term *free cross-sectional area* means, even in the case of a pre-insulated duct, the area calculated on the basis of the inner dimensions of the duct itself and not the insulation.)

.1 the ducts are to be made of non-combustible material, which may be faced internally and externally with membranes having low flame-spread characteristics and, in each case, a calorific value** not exceeding 45 [MJ/m^2] of their surface area for the thickness used;

(**Refer to the recommendations published by the International Organization for Standardization, in particular publication ISO 1716:2002, Reaction to the fire tests for building products – Determination of the heat of combustion.)

.2 the ducts are only used at the end of the ventilation device; and

.3 the ducts are not situated less than 600 [mm], measured along the duct, from an opening in an "A" or "B" class division, including continuous "B" class ceiling.

IR 3.7.1.1 With respect only to 3.7.1.1 above, a ventilation duct made of material other than steel may be considered equivalent to a ventilation duct made of steel, provided the material is non-combustible and has passed a standard fire test in accordance with Annex 1: Part 3 of the FTP code as non-load bearing structure for 30 minutes following the requirements for testing “B” class divisions.

3.7.1.2 The following arrangements are to be tested in accordance with the Fire Test Procedures Code:

.1 fire dampers, including their relevant means of operation, however, the testing is not required for dampers located at the lower end of the duct in exhaust ducts for galley ranges, which must be of steel and capable of stopping the draught in the duct; and

.2 duct penetrations through "A" class divisions. However, the test is not required where steel sleeves are directly joined to ventilation ducts by means of riveted or screwed connections or by welding.

3.7.1.3 Fire dampers are to be easily accessible. Where they are placed behind ceilings or linings, these ceilings or linings are to be provided with an inspection hatch on which the identification number of the fire damper is marked. The fire damper identification number is also to be marked on any remote controls provided.

3.7.1.4 Ventilation ducts are to be provided with hatches for inspection and cleaning. The hatches are to be located near the fire dampers.

3.7.1.5 The main inlets and outlets of ventilation systems are to be capable of being closed from outside the spaces being ventilated. The means of closing is to be easily accessible as well as prominently and permanently marked and is to indicate the operating position of the closing device.

3.7.1.6 Combustible gaskets in flanged ventilation duct connections are not permitted within 600 [mm] of openings in "A" or "B" class divisions and in ducts required to be of "A" class construction.

3.7.1.7 Ventilation openings or air balance ducts between two enclosed spaces are not to be provided except as permitted by paragraphs 3.4.1.2.1 and 3.4.2.3.

3.7.2 Arrangement of ducts

3.7.2.1 The ventilation systems for machinery spaces of category A, vehicle spaces, ro-ro spaces, galleys, special category spaces and cargo spaces shall, in general, be separated from each other and from the ventilation systems serving other spaces. However, the galley ventilation systems on cargo ships of less than 4,000 gross tonnage and in passenger ships carrying not more than 36 passengers need not be completely separated from other ventilation systems, but may be served by separate ducts from a ventilation unit serving other spaces. In such a case, an automatic fire damper is to be fitted in the galley ventilation duct near the ventilation unit.

3.7.2.2 Ducts provided for the ventilation of machinery spaces of category A, galleys, vehicle spaces, ro-ro spaces or special category spaces are not to pass through accommodation spaces, service spaces, or control stations unless they comply with paragraph 3.7.2.4.

3.7.2.3 Ducts provided for the ventilation of accommodation spaces, service spaces or control stations are not to pass through machinery spaces of category A, galleys, vehicle spaces, ro-ro spaces or special category spaces unless they comply with paragraph 3.7.2.4.

3.7.2.4 As permitted by paragraphs 3.7.2.2 and 3.7.2.3 ducts are to be either:

.1 constructed of steel having a thickness of at least;

a) 3 [mm] for ducts with a free cross-sectional area of less than 0.075 [m^2],

b) 4 [mm] for ducts with a free cross-sectional area of between 0.075 [m^2] and 0.45 [m^2], and

c) at least 5 [mm] for ducts with a free cross-sectional area of over 0.45 [m^2];

.2 suitably supported and stiffened;

.3 fitted with automatic fire dampers close to the boundaries penetrated; and

IR .3 Fire dampers are to be preferably fitted in the space having low fire risk

.4 insulated to "A-60" class standard from the boundaries of the spaces they serve to a point at least 5 [m] beyond each fire damper;

or

.1 constructed of steel in accordance with paragraphs 3.7.2.4.1.1 and 3.7.2.4.1.2; and

.2 insulated to "A-60" class standard throughout the spaces they pass through, except for ducts that pass through spaces of category (9) or (10) as defined in paragraph 3.2.2.3.2.2.

3.7.2.5 For the purposes of paragraphs 3.7.2.4.1.4 and 3.7.2.4.2.2, ducts are to be insulated over their entire cross-sectional external surface. Ducts that are outside but adjacent to the specified space, and share one or more surfaces with it, are to be considered to pass through the specified space, and are to be insulated over the surface they share with the space for a distance of 450 [mm] past the duct.

IR3.7.2.5 For determining the extent of insulation when the duct passes through an enclosed space, See Fig. 3.7.2.5.

3.7.2.6 Where it is necessary that a ventilation duct passes through a main vertical zone division, an automatic fire damper is to be fitted adjacent to the division. The damper is also to be capable of being manually closed from each side of the division. The control location is to be readily accessible and be clearly and prominently marked. The duct between the division and the damper is to be constructed of steel in accordance with paragraphs 3.7.2.4.1.1 and 3.7.2.4.1.2 and insulated to at least the same fire integrity as the division penetrated. The damper is to be fitted on at least one side of the division with a visible indicator showing the operating position of the damper.

IR3.7.2.6 When the galley is served by a duct from a common ventilation unit and not from an independent unit, automatic fire damper is to be provided outside the galley, irrespective of the size of the duct.

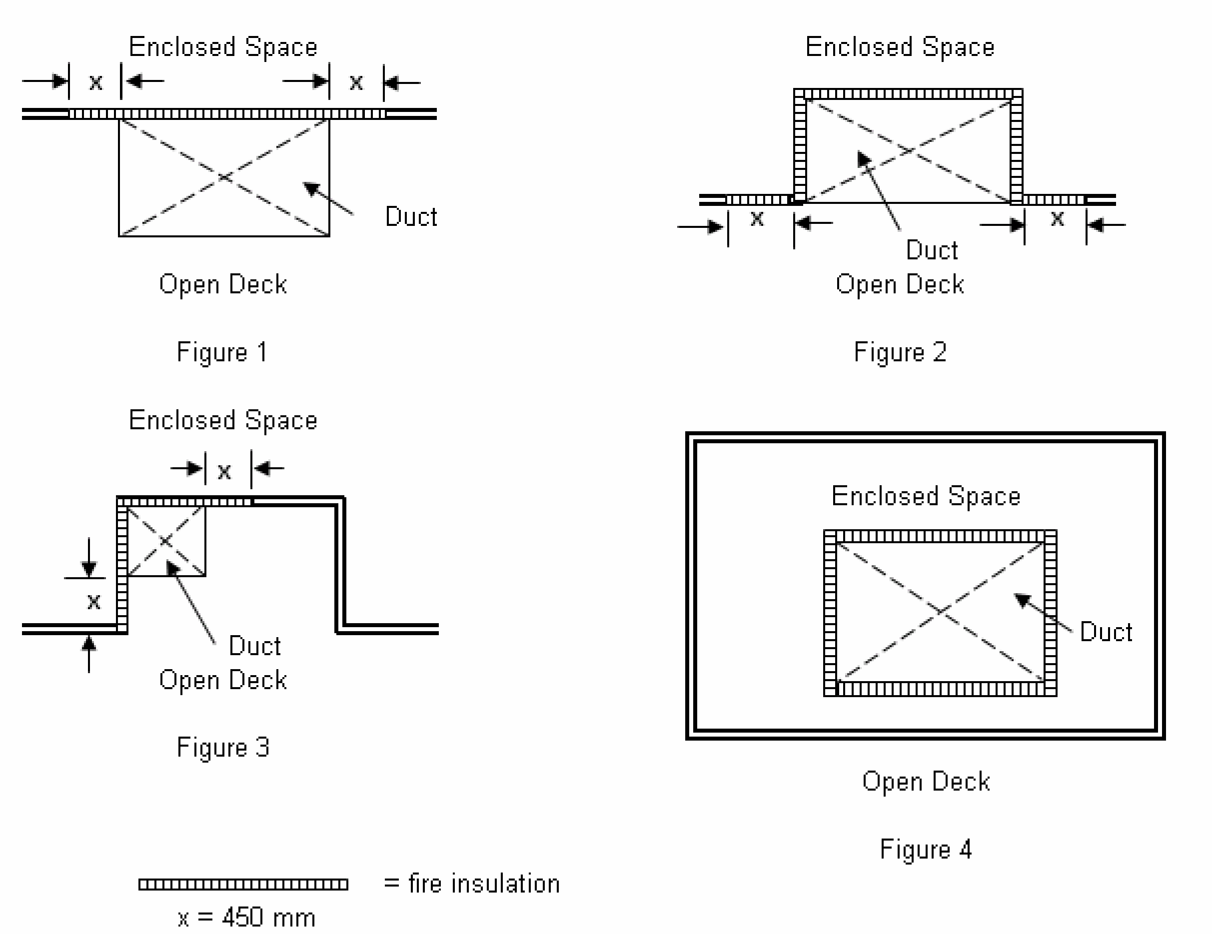


Fig.3.7.2.5 : Examples of galley ducts contiguous to enclosed spaces

3.7.3 Details of fire dampers and duct penetrations

3.7.3.1 Ducts passing through "A" class divisions are to meet the following requirements:

.1 where a thin plated duct with a free cross sectional area equal to, or less than, 0.02 [m^2] passes through "A" class divisions, the opening is to be fitted with a steel sheet sleeve having a thickness of at least 3 [mm] and a length of at least 200 [mm], divided preferably into 100 [mm] on each side of a bulkhead or, in the case of a deck, wholly laid on the lower side of the decks penetrated;

.2 where ventilation ducts with a free cross-sectional area exceeding 0.02 [m^2], but not more than 0.075 [m^2], pass through "A" class divisions, the openings are to be lined with steel sheet sleeves. The ducts and sleeves are to have a thickness of at least 3 [mm] and a length of at least 900 [mm]. When passing through bulkheads, this length is to be divided preferably into 450 [mm] on each side of the bulkhead. These ducts, or sleeves lining such ducts, are to be provided with fire insulation. The insulation is to have at least the same fire integrity as the division through which the duct passes; and

.3 automatic fire dampers are to be fitted in all ducts with a free cross-sectional area exceeding 0.075 [m^2] that pass through "A" class divisions. Each damper is to be fitted close to the division penetrated and the duct between the damper and the division penetrated is to be constructed of steel in accordance with paragraphs 3.7.2.4.2.1 and 3.7.2.4.2.2. The fire damper is to operate automatically, but is also to be capable of being closed manually from both sides of the division. The damper is to be fitted with a visible indicator which shows the operating position of the damper. Fire dampers are not required, however, where ducts pass through spaces surrounded by "A" class divisions, without serving those spaces, provided those ducts have the same fire integrity as the divisions which they penetrate. A duct of cross-sectional area exceeding 0.075 [m^2] is not to be divided into smaller ducts at the penetration of an "A" class division and then recombined into the original duct once through the division to avoid installing the damper required by this provision.

3.7.3.2 Ventilation ducts with a free cross-sectional area exceeding 0.02 [m^2] passing through "B" class bulkheads shall be lined with steel sheet sleeves of 900 [mm] in length, divided preferably into 450 [mm] on each side of the bulkheads unless the duct is of steel for this length.

3.7.3.3 All fire dampers are to be capable of manual operation. The dampers are to have a direct mechanical means of release or, alternatively, be closed by electrical, hydraulic, or pneumatic operation. All dampers are to be manually operable from both sides of the division. Automatic fire dampers, including those capable of remote operation, are to have a failsafe mechanism that will close the damper in a fire even upon loss of electrical power or hydraulic or pneumatic pressure loss. Remotely operated fire dampers are to be capable of being reopened manually at the damper.

3.7.4 Ventilation systems for passenger ships carrying more than 36 passengers

3.7.4.1 In addition to the requirements in sections 3.7.1, 3.7.2 and 3.7.3, the ventilation system of a passenger ship carrying more than 36 passengers is also to meet the following requirements.

3.7.4.2 In general, the ventilation fans are to be so arranged that the ducts reaching the various spaces remain within a main vertical zone.

3.7.4.3 Stairway enclosures are to be served by an independent ventilation fan and duct system (exhaust and supply) which is not to serve any other spaces in the ventilation systems.

3.7.4.4 A duct, irrespective of its cross-section, serving more than one 'tween-deck accommodation space, service space or control station, is to be fitted, near the penetration of each deck of such spaces, with an automatic smoke damper that is also to be capable of being closed manually from the protected deck above the damper. Where a fan serves more than one 'tween-deck space through separate ducts within a main vertical zone, each dedicated to a single 'tween-deck space, each duct is to be provided with a manually operated smoke damper fitted close to the fan.

3.7.4.5 Vertical ducts , if necessary are to, be insulated as required by tables 3.1 and 3.2. Ducts are to be insulated as required for decks between the space they serve and the space being considered, as applicable.

3.7.5 Exhaust ducts from galley ranges

3.7.5.1 Requirements for passenger ships carrying more than 36 passengers

3.7.5.1.1 In addition to the requirements in sections 3.7.1, 3.7.2 and 3.7.3, exhaust ducts from galley ranges are to be constructed in accordance with paragraphs 3.7.2.4.2.1 and 3.7.2.4.2.2 and insulated to "A-60" class standard throughout accommodation spaces, service spaces, or control stations they pass through. They are also to be fitted with:

.1 a grease trap readily removable for cleaning unless an alternative approved grease removal system is fitted;

.2 a fire damper located in the lower end of the duct at the junction between the duct and the galley range hood which is automatically and remotely operated and, in addition, a remotely operated fire damper located in the upper end of the duct close to the outlet of the duct;

.3 a fixed means for extinguishing a fire within the duct*;

(*Refer to the recommendations published by the International Organization for Standardization, in particular publication ISO 15371:2009, Ships and marine technology – Fire-extinguishing systems for protection of galley cooking equipment.)

.4 remote-control arrangements for shutting off the exhaust fans and supply fans, for operating the fire dampers mentioned in paragraph 3.7.5.1.1.2 and for operating the fire-extinguishing system, which is to be placed in a position outside the galley close to the entrance to the galley. Where a multi-branch system is installed, a remote means located with the above controls shall be provided to close all branches exhausting through the same main duct before an extinguishing medium is released into the system; and

.5 suitably located hatches for inspection and cleaning, including one provided close to the exhaust fan and one fitted in the lower end where grease accumulates.

3.7.5.1.2 Exhaust ducts from ranges for cooking equipment installed on open decks are to conform to paragraph 3.7.5.1.1, as applicable, when passing through accommodation spaces or spaces containing combustible materials.

3.7.5.2 Requirements for cargo ships and passenger ships carrying not more than 36 passengers

When passing through accommodation spaces or spaces containing combustible materials, the exhaust ducts from galley ranges are to be constructed in accordance with paragraphs 3.7.2.4.1.1 and 3.7.2.4.1.2. Each exhaust duct is to be fitted with:

.1 a grease trap readily removable for cleaning;

.2 an automatically and remotely operated fire damper located in the lower end of the duct at the junction between the duct and the galley range hood and, in addition, a remotely operated fire damper in the upper end of the duct close to the outlet of the duct;

.3 arrangements, operable from within the galley, for shutting off the exhaust and supply fans; and

.4 fixed means for extinguishing a fire within the duct.*

(*Refer to the recommendations published by the International Organization for Standardization, in particular publication ISO 15371:2009, Ships and marine technology – Fire-extinguishing systems for protection of galley cooking equipment.)

3.7.6 Ventilation rooms serving machinery spaces of category A containing internal combustion machinery

3.7.6.1 Where a ventilation room serves only such an adjacent machinery space and there is no fire division between the ventilation room and the machinery space, the means for closing the ventilation duct or ducts serving the machinery space shall be located outside of the ventilation room and machinery space.

3.7.6.2 Where a ventilation room serves such a machinery space as well as other spaces and is separated from the machinery space by a "A-0" class division, including penetrations, the means for closing the ventilation duct or ducts for the machinery space can be located in the ventilation room.

3.7.7 Ventilation systems for laundries in passenger ships carrying more than 36 passengers

Exhaust ducts from laundries and drying rooms of category (13) spaces as defined in paragraph 3.2.2.3.2.2 are to be fitted with:

.1 filters readily removable for cleaning purposes;

.2 a fire damper located in the lower end of the duct which is automatically and remotely operated;

.3 remote-control arrangements for shutting off the exhaust fans and supply fans from within the space and for operating the fire damper mentioned in paragraph 3.7.7.2; and

.4 suitably located hatches for inspection and cleaning.

Section 4

Fire Fighting

4.1 Purpose

4.1.1 The purpose of this section is to suppress and swiftly extinguish a fire in the space of origin, except for 4.1.2. For this purpose, the following functional requirements are to be met:

.1 fixed fire extinguishing systems are to be installed having due regard to the fire growth potential of the protected spaces; and

.2 fire extinguishing appliances are to be readily available.

4.1.2 For open-top container holds* and on deck container stowage areas on ships designed to carry containers on or above the weather deck, constructed on or after 1 January 2016, fire protection arrangements are to be provided for the purpose of containing a fire in the space or area of origin and cooling adjacent areas to prevent fire spread and structural damage.

(*For a definition of this term, refer to the Interim guidelines for open-top containerships (MSC/Circ.608/Rev.1).)

4.2 Water supply systems

Every ship is to be provided with fire pumps, fire mains, hydrants and hoses complying as applicable with the following requirements.

4.2.1 *Fire mains and hydrants*

4.2.1.1 *General*

Materials readily rendered ineffective by heat are not to be used for fire mains and hydrants unless adequately protected. The pipes and hydrants are to be so placed that the fire hoses may be easily coupled to them. The arrangement of pipes and hydrants is to be such as to avoid the possibility of freezing. Suitable drainage arrangement is to be provided for fire main piping. Isolation valves are to be installed for all open deck fire main branches used for purposes other than fire fighting. In ships where deck cargo may be carried, the positions of the hydrants are to be such that they are always readily accessible and the pipes are to be arranged as far as practicable to avoid risk of damage by such cargo.

4.2.1.2 *Ready availability of water supply*

The arrangements for the ready availability of water supply is to be:

.1 in passenger ships:

a) of 1,000 gross tonnage and upwards such that at least one effective jet of water is immediately available from any hydrant in an interior location and so as to ensure the continuation of the output of water by the automatic starting of one required fire pump;

b) of less than 1,000 gross tonnage by automatic start of at least one fire pump or by remote starting from the navigation bridge of at least one fire pump. If the pump starts automatically or if the bottom valve cannot be opened from where the pump is remotely started, the bottom valve is to be always kept open; and

c) in passenger ships, if fitted with periodically unattended machinery spaces, the arrangements will be specially considered.

.2 in cargo ships:

a) to the satisfaction of IRS; and

b) with a periodically unattended machinery space or when only one person is required on watch there is to be immediate water delivery from the fire main system at a suitable pressure, either by remote starting of one of the main fire pumps with remote starting from the navigating bridge and fire control station, if any, or permanent pressurization of the fire main system by one of the main fire pumps, except that this requirement may be waived for cargo ships of less than 1,600 tons gross tonnage if the fire pump starting arrangement in the machinery space is in an easily accessible position;

c) For vessels intended for ice class notation, See also Pt.5.

4.2.1.3 *Diameter of fire mains*

The diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously, except that in the case of cargo ships, other than those included in 4.7.3.2, the diameter need only be sufficient for the discharge of 140 [m^3/hour].

4.2.1.4 *Isolating valves and relief valves*

4.2.1.4.1 Isolating valves to separate the section of the fire main within the machinery space containing the main fire pump or pumps from the rest of the fire main are to be fitted in an easily accessible and tenable position outside the machinery spaces. The fire main is to be so arranged that when the isolating valves are shut all the hydrants on the ship, except those in the machinery space referred to above, can be supplied with water by another fire pump or an emergency fire pump. The emergency fire pump, its seawater inlet, and suction and delivery pipes and isolating valves are to be located outside the machinery space. If this arrangement cannot be made, the sea-chest may be fitted in the machinery space if the valve (i.e. sea inlet valve) is remotely controlled from a position in the same compartment as the emergency fire pump and the suction pipe is as short as practicable. Short lengths of suction or discharge piping may penetrate the machinery space, provided they are enclosed in a substantial steel casing, or are insulated to A-60 class standards. The pipes are to have substantial wall thickness, but in no case less than 11 [mm] and are to be welded except for the flanged connection to the sea inlet valve.

IR4.2.1.4.1

a) Any part of the fire main routed through a category ‘A’ machinery space is to be fitted with isolating valves outside the space. The arrangements of fire mains is to allow for fire water from the fire pumps or emergency fire pump to reach all hydrants outside the isolated space. Isolation requirements of 4.2.1.4.1 are not applicable to the piping from fire pumps located in spaces other than category ‘A’ machinery spaces.

b) In cases where suction or discharge piping penetrating machinery spaces are required to be enclosed in a substantial steel casing, or insulated to “A-60” class standards, it is not necessary to enclose or insulate “sea inlet valves”, “sea chests” and “distance pieces between the sea inlet valves and shell plating / sea chests”;

c) The method for insulating pipes to ““A-60” class standards” is to be such that the pipes are covered/protected in a practical manner by insulation material which is approved as a part of “A-60” class divisions in accordance with the FTP Code; and

d) Where the sea inlet valve is in the machinery space, the valve is not to be a fail-close type. Where the sea inlet valve is in the machinery space and is not a fail-open type, measures are to be taken so that the valve can be opened in the event of fire, e.g. control piping, actuating devices and/or electric cables with fire resistant protection equivalent to “A-60” class standards.

e) In cases where main fire pumps are provided in a compartment outside machinery spaces and where the emergency fire pump suction or discharge piping penetrates such compartment, the above requirement is to be applied to the piping.

4.2.1.4.2 A valve is to be fitted to serve each fire hydrant so that any fire hose may be removed while the fire pumps are at work.

4.2.1.4.3 Relief valves are to be provided in conjunction with all fire pumps if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system.

4.2.1.4.4 In tankers isolation valves are to be fitted in the fire main at poop front in a protected position and on the tank deck at intervals of not more than 40 [m] to preserve the integrity of the fire main system in case of fire or explosion.

4.2.1.5 *Number and position of hydrants*

4.2.1.5.1 The number and position of hydrants are to be such that at least two jets of water not emanating from the same hydrant, one of which is to be from a single length of hose, may reach any part of the ship normally accessible to the passengers or crew while the ship is being navigated and any part of any cargo space when empty, any ro-ro space or any vehicle space in which latter case the two jets is to reach any part of the space, each from a single length of hose. Furthermore, such hydrants are to be positioned near the accesses to the protected spaces.

IR4.2.1.5.1 In ships of 1000 tons gross tonnage and over, at least two hydrants are to be provided in the machinery spaces.

4.2.1.5.2 In addition to the requirements in 4.2.1.5.1, passenger ships are to comply with the following:

.1 in the accommodation, service and machinery spaces the number and position of hydrants are to be such that the requirements of 4.2.1.5.1 may be complied with when all watertight doors and all doors in main vertical zone bulkheads are closed; and

.2 where access is provided to a machinery space of category A at a low level from an adjacent shaft tunnel, two hydrants are to be provided external to, but near the entrance to that machinery space. Where such access is provided from other spaces, in one of those spaces two hydrants are to be provided near the entrance to the machinery space of category A. Such provision need not be made where the tunnel or adjacent spaces are not part of the escape route.

IR4.2.1.5.3 In cargo ships of 2,000 tons gross tonnage and over, a hydrant is to be provided in the shaft tunnel adjacent to the engine room watertight door.

4.2.1.6 *Pressure at hydrants*

With the two pumps simultaneously delivering water through the nozzles specified in 4.2.3.3, with the quantity of water as specified in 4.2.1.3, through any adjacent hydrants, the following minimum pressures are to be maintained at all hydrants:

.1 for passenger ships:

4,000 gross tonnage and upwards 0.40 [N/mm^2]
less than 4,000 gross tonnage 0.30 [N/mm^2];

.2 for cargo ships,

6,000 gross tonnage and upwards 0.27 [N/mm^2]
less than 6,000 gross tonnage; 0.25 [N/mm^2]; and

.3 the maximum pressure at any hydrant is not to exceed that at which the effective control of a fire hose can be demonstrated.

4.2.1.7 *International shore connection*

4.2.1.7.1 Ships of 500 gross tonnage and upwards is to be provided with at least one international shore connection complying with the Fire Safety Systems Code (Chapter 8).

4.2.1.7.2 Facilities are to be available enabling such a connection to be used on either side of the ship.

4.2.2 Fire pumps

4.2.2.1 *Pumps accepted as fire pumps*

Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil and that if they are subject to occasional duty for the transfer or pumping of oil fuel, suitable change-over arrangements are fitted.

4.2.2.2 *Number of fire pumps*

Ships are to be provided with independently driven fire pumps as follows:

.1 in passenger ships of:

4,000 gross tonnage and upwards	:	at least three
less than 4,000 gross tonnage	:	at least two

.2 in cargo ships of:

1,000 gross tonnage and upwards	:	at least two

less than 1,000 gross tonnage : at least two power driven pumps, one of which is to be independently driven.

4.2.2.3 *Arrangement of fire pumps and fire mains*

4.2.2.3.1 *Fire pumps*

The arrangement of sea connections, fire pumps and their sources of power are to be such as to ensure that:

.1 in passenger ships of 1,000 gross tonnage and upwards, in the event of a fire in any one compartment all the fire pumps will not be put out of action; and

.2 in passenger ships of less than 1,000 gross tonnage and in cargo ships of 500 gross tonnage and upwards, if a fire in any one compartment could put all the pumps out of action, there is to be an alternative means consisting of an emergency fire pump complying with the provisions of the Fire Safety Systems Code (Chapter 8) with its source of power and sea connection located outside the space where the main fire pumps or their sources of power are located. (See also 4.2.1.4.1).

IR.2.1 Unless the main fire pumps, their sea suctions and the fuel supply or source of power for each pump are situated within compartments separated at least by A-0 divisions, it is considered for the purpose of para 2 above, that the fire in any one compartment would put the pumps out of action.

IR .2.2 An arrangement in which two main fire pumps are located in adjacent compartments which share more than one boundary will also require an emergency fire pump.

4.2.2.3.2 *Requirements for the space containing the emergency fire pump*

.1 *Location of the space*

The space containing the fire pump are not to be contiguous to the boundaries of machinery spaces of category A or those spaces containing main fire pumps. Where this is not practicable, the common bulkhead between the two spaces are to be insulated to a standard of structural fire protection equivalent to that required for a control station in 3.2.3.3. The insulation is to extend at least 450 [mm] outside the area of the common boundary.

.2 *Access to the emergency fire pump*

No direct access is to be permitted between the machinery space and the space containing the emergency fire pump and its source of power. When this is impracticable, IRS may accept an arrangement where the access is by means of an airlock with the door of the machinery space being of A-60 class standard, and the other door being at least steel, both reasonably gastight, self-closing and without any hold back arrangements. Alternatively, the access may be through a watertight door capable of being operated from a space remote from the machinery space and the space containing the emergency fire pump and unlikely to be cut off in the event of fire in those spaces. In such cases, a second means of access to the space containing the emergency fire pump and its source of power is to be provided.

IR.2 When a single access to the emergency fire pump room is through another space adjoining a machinery space of category ‘A’ or the spaces containing the main fire pumps, class ‘A-60’ boundary is to be provided between that other space and the machinery space of category ‘A’ or the spaces containing main fire pumps.

.3 Lighting and v*entilation of the emergency fire pump space*

Ventilation arrangements to the space containing the independent source of power for the emergency fire pump are to be such as to preclude, as far as practicable, the possibility of smoke from a machinery space fire entering or being drawn into that space.

IR.3 The room where the emergency fire pump prime mover is located is to be illuminated from the emergency source of supply and is to be well ventilated. If the room is to be mechanically ventilated, the power is to be supplied by the emergency source.

IR .4 Maintenance / inspection

The room(s) where the pump and prime mover are installed is/are to have adequate space for maintenance work and inspections.

4.2.2.3.3 *Additional pumps for cargo ships*

In addition, in cargo ships where other pumps, such as general service, bilge and ballast, etc., are fitted in a machinery space, arrangements are to be made to ensure that at least one of these pumps, having the capacity and pressure required by 4.2.1.6.2 and 4.2.2.4.2, is capable of providing water to the fire main.

IR4.2.2.3.3 However, in cases where the required number and capacity of fire pumps is already available otherwise, the capacity and pressure characteristics of the general service/bilge/ballast pumps required to be connected as per 4.2.2.3.3, would be specially considered in view of the optimal characteristics required for their primarily intended services.

IR4.2.2.3.4 Where the emergency fire pump is electrically driven, the power is to be supplied by a source other than that supplying the main fire pump and be located outside the engine room, and separated from it by an A class division. The relevant electrical cables are not to pass through the compartment containing the main fire pump.

4.2.2.4 *Capacity of fire pumps*

4.2.2.4.1 *Total capacity of required fire pumps*

The required fire pumps are to be capable of delivering for fire-fighting purposes a quantity of water, at the pressure specified in 4.2.1.6, as follows:

.1 pumps in passenger ships, the quantity of water is not less than two thirds of the quantity required to be dealt with by the bilge pumps (See Pt.4, Ch.3, Sec.2 for capacity and number of bilge pumps) when employed for bilge pumping; and

.2 pumps in cargo ships, other than any emergency pump, the quantity of water is not less than four thirds of the quantity required to be dealt with by each of the independent bilge pumps when employed for bilge pumping, except that in no cargo ship, other than those included in 4.7.3.2, need the total required capacity of the fire pumps exceed 180 [m^3/h]. (See Pt.4, Ch.3, Sec.2 for capacity of bilge pumps).

IR.2 On board cargo ships designed to carry five or more tiers of containers on or above the weather deck, the total capacity of the main fire pumps need not exceed 180 [m^3/h] in case the mobile water monitors are supplied by separate pumps and piping system.

4.2.2.4.2 *Capacity of each fire pump*

Each of the required fire pumps (other than any emergency pump required in 4.2.2.3.1.2 for cargo ships) are to have a capacity not less than 80% of the total required capacity divided by the minimum number of required fire pumps but in any case not less than 25 [m^3/h] and each such pump are in any event to be capable of delivering at least the two required jets of water. These fire pumps are to be capable of supplying the fire main system under the required conditions. Where more pumps than the minimum of required pumps are installed such additional pumps are to have a capacity of at least 25 [m^3/h] and are to be capable of delivering at least the two jets of water required in 4.2.1.5.1.

4.2.3 Fire hoses and nozzles

4.2.3.1 *General specifications*

4.2.3.1.1 Fire hoses are to be of approved non-perishable material and are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Each hose is to be provided with a nozzle and the necessary couplings. Hoses specified in this chapter as "fire hoses" together with any necessary fittings and tools are to be kept ready for use in conspicuous positions near the water service hydrants or connections. Additionally, in interior locations in passenger ships carrying more than 36 passengers fire hoses are to be connected to the hydrants at all times. Fire hoses are to have a length of at least 10 [m], but not more than:

.1 15 [m] in machinery spaces;

.2 20 [m] in other spaces and open decks; and

.3 25 [m] for open decks on ships with a maximum breadth in excess of 30 [m].

4.2.3.1.2 Unless one hose and nozzle is provided for each hydrant in the ship, there is to be complete interchangeability of hose couplings and nozzles.

4.2.3.2 *Number and diameter of fire hoses*

4.2.3.2.1 Ships are to be provided with such number and diameter of hoses as are appropriate to the type of ship.

4.2.3.2.2 In passenger ships, there is to be at least one fire hose for each of the hydrants required by 4.2.1.5 and these hoses are to be used only for the purposes of extinguishing fires or testing the fire-extinguishing apparatus at fire drills and surveys.

4.2.3.2.3 In cargo ships:

.1 of 1,000 gross tonnage and upwards, the number of fire hoses to be provided is to be one for each 30 [m] length of the ship and one spare but in no case less than five in all. This number does not include any hoses required in any engine or boiler room. If necessary the number of hoses is to be increased so as to ensure that hoses in sufficient number are available and accessible at all times, having regard to the type of ship and the nature of trade in which the ship is employed. Ships carrying dangerous goods in accordance with Ch.7, Sec.2 are to be provided with 3 hoses and nozzles, in addition to those required above; and

.2 of less than 1,000 gross tonnage, the number of fire hoses to be provided are to be calculated in accordance with the provisions of 4.2.3.2.3.1. However, the number of hoses are in no case to be less than three.

IR.3 All hydrants in the machinery spaces of ships with oil fire boilers or internal combustion type propelling machinery are to be fitted with hoses having the nozzles in accordance with 4.2.3.3.

4.2.3.3 *Size and types of nozzles*

4.2.3.3.1 For the purposes of this part, standard nozzle sizes are to be 12 [mm], 16 [mm] and 19 [mm] or as near thereto as possible. Larger diameter nozzles may be permitted at the discretion of IRS.

4.2.3.3.2 For accommodation and service spaces, a nozzle size greater than 12 [mm] need not be used.

4.2.3.3.3 For machinery spaces and exterior locations, the nozzle sizes are to be such as to obtain the maximum discharge possible from two jets at the pressure mentioned in 4.2.1.6 from the smallest pump, provided that a nozzle size greater than 19 [mm] need not be used.

4.2.3.3.4 Nozzles are to be of an approved dual-purpose type (i.e., spray / jet type) incorporating a shutoff.

IR4.2.3.3.4 Aluminium alloys may be used for fire hose couplings and nozzles, except in open deck areas of oil tankers and chemical tankers.

4.3 Portable fire extinguishers

4.3.1 Type and design

Portable fire extinguishers are to comply with the requirements of the Fire Safety Systems Code (Chapter 8).

4.3.2 Arrangement of fire extinguishers (Also refer MSC.1/Circ.1275 'Unified Interpretations of SOLAS Chapter II-2 on the Number and Arrangement of Portable Fire Extinguishers on Board Ships')

4.3.2.1 Accommodation spaces, service spaces and control stations are to be provided with portable fire extinguishers of appropriate types and in sufficient number to the satisfaction of the Administration. Ships of 1,000 gross tonnage and upwards are to carry at least five portable fire extinguishers.

IR4.3.2.1 For ships of under 1,000 gross tonnage the above number of extinguishers is not be less than three.

4.3.2.2 One of the portable fire extinguishers intended for use in any space is to be stowed near the entrance to that space.

4.3.2.3 Carbon dioxide fire extinguishers are not to be placed in accommodation spaces. In control stations and other spaces containing electrical or electronic equipment or appliances necessary for the safety of the ship, fire extinguishers whose extinguishing media are neither electrically conductive nor harmful to the equipment and appliances are to be provided.

4.3.2.4 Fire extinguishers are to be situated ready for use at easily visible places, which can be reached quickly and easily at any time in the event of a fire, and in such a way that their serviceability is not impaired by the weather, vibration or other external factors. Portable fire extinguishers are to be provided with devices which indicate whether they have been used.

IR4.3.2.5 For galleys and for spaces containing domestic boilers, one portable fire extinguisher suitable for dealing with oil fires or fires in electric cooking equipment, as appropriate, is to be provided.

4.3.3 Spare charges

4.3.3.1 Spare charges are to be provided for 100% of the first 10 extinguishers and 50% of the remaining fire extinguishers capable of being recharged on board. Not more than 60 total spare charges are required. Instructions for recharging are to be carried on board.

4.3.3.2 For fire extinguishers which cannot be recharged onboard, additional portable fire extinguishers of the same quantity, type, capacity and number as determined in 4.3.3.1 above are to be provided in lieu of spare charges.

4.4 Fixed fire-extinguishing systems

4.4.1 Types of fixed fire extinguishing systems

4.4.1.1 A fixed fire extinguishing system required by 4.5 below may be any of the following:

.1 a fixed gas fire-extinguishing system complying with the provisions of the Fire Safety Systems Code (Chapter 8);

.2 a fixed high-expansion foam fire-extinguishing system complying with the provisions of the Fire Safety Systems Code (Chapter 8); and

.3 a fixed pressure water-spraying fire-extinguishing system complying with the provisions of the Fire Safety Systems Code (Chapter 8).

4.4.1.2 Where a fixed fire-extinguishing system not required by this part is installed, it is to meet the relevant requirement of this part and the Fire Safety Systems Code (Chapter 8).

4.4.1.3 Fire-extinguishing systems using Halon 1211, 1301, and 2402 and perfluorocarbons are to be prohibited.

4.4.1.4 Steam is not generally accepted as a fire-extinguishing medium in fixed fire-extinguishing systems. However, restricted use of steam is permitted as an addition to the required fire-extinguishing system and is to comply with the requirements of the Fire Safety System Code (Chapter 8).

4.4.1.5 On ships constructed before 1 July 2002, fixed carbon dioxide fire-extinguishing systems for the protection of machinery spaces and cargo pump-rooms shall comply with the provisions of 5.2.2.2 of Section 5 of Chapter 8 “Fire Safety Systems Code”, by the first scheduled dry-docking after 1 January 2010.

4.4.2 Closing appliances for fixed gas fire-extinguishing systems

Where a fixed gas fire-extinguishing system is used, openings which may admit air to, or allow gas to escape from, a protected space is to be capable of being closed from outside the protected space.

4.4.3 Storage rooms of fire-extinguishing medium

When the fire-extinguishing medium is stored outside a protected space, it is to be stored in a room which is located aft of the forward collision bulkhead, and is used for no other purposes. Any entrance to such a room is preferably to be from the open deck and is to be independent of the protected space.

Additionally, storage rooms for fixed gas fire extinguishing media are to meet the following requirements:

a) If the storage space is located below deck, it is to be located no more than one deck below the open deck and is to directly accessible by a stairway or ladder from the open deck.

b) Storage spaces located below deck or spaces located above deck but not provided with access from the open deck, are to be fitted with a mechanical ventilation system designed to take exhaust air from the bottom of the space and sized to provide at least 6 air changes per hour. Where located above deck and having direct access from the open deck, natural ventilation may suffice.

c) Access doors are to open outwards, and the bulkheads and decks including doors and other means of closing any opening therein, which form the boundaries between such rooms and adjacent enclosed spaces are to be gastight. For the purpose of the application of Table 3.1 to Table 3.8, such storage rooms are to be treated as fire control stations.

IR4.4.3 Fire extinguishing media protecting the cargo holds may be stored in a room located forward of the cargo holds but aft of the collision bulkheads, provided that both the local manual release mechanism and remote control(s) for the release of the media are fitted, and the latter is of robust construction or so protected as to remain operable in case of fire in protected spaces. The remote control is to be placed in the accommodation area in order to facilitate their ready accessibility by the crew. The capability to release different quantities of fire extinguishing media into different cargo holds so protected is to be included in the remote release arrangement.

4.4.4 Water pumps for other fire-extinguishing systems

Pumps, other than those serving the fire main, required for the provision of water for fire-extinguishing systems required by this part, their sources of power and their controls are to be installed outside the space or spaces protected by such systems and are to be so arranged that a fire in the space or spaces protected will not put any such system out of action.

4.5 Fire extinguishing arrangements in machinery spaces

4.5.1 Machinery spaces containing oil-fired boilers or oil fuel units (Also see Table 4.5.1)

4.5.1.1 *Fixed fire-extinguishing systems*

Machinery spaces of category A containing oil-fired boilers or oil fuel units are to be provided with any one of the fixed fire-extinguishing systems in 4.4.1. In each case, if the engine and boiler rooms are not entirely separate, or if fuel oil can drain from the boiler room into the engine-room, the combined engine and boiler rooms are to be considered as one compartment.

IR 4.5.1.1 Machinery spaces of Category A where oil fuel of flash point less than 60°C is used

The fixed installation is to be of gas type as in 4.4.1.1.1 in all cases where the flash point of oil fuel is less than 60°C. (See Ch.2, 1.2.1).

4.5.1.2 *Additional fire-extinguishing arrangements* (Also refer MSC.1/Circ.1275 'Unified Interpretations of SOLAS Chapter II-2 on the Number and Arrangement of Portable Fire Extinguishers on Board Ships'.

4.5.1.2.1 There are to be in each boiler room or at an entrance outside of the boiler room at least one portable foam applicator unit complying with the provisions of the Fire Safety Systems Code.

4.5.1.2.2 There are to be at least two portable foam extinguishers or equivalent in each firing space in each boiler room and in each space in which a part of the oil fuel installation is situated. There is to be not less than one approved foam-type extinguisher of at least 135 *l* capacity or equivalent in each boiler room. These extinguishers are to be provided with hoses on reels suitable for reaching any part of the boiler room. In the case of domestic boilers of less than 175 kW an approved foam-type extinguisher of at least 135 *l* capacity is not required.

4.5.1.2.3 In each firing space there is to be a receptacle containing at least 0.1 [m^3] sand, sawdust impregnated with soda, or other approved dry material, along with a suitable shovel for spreading the material. An approved portable extinguisher may be substituted as an alternative.

4.5.2 Machinery spaces of Category A containing internal combustion machinery (Also See Table 4.5.1)

4.5.2.1 *Fixed fire-extinguishing systems*

Machinery spaces of category A containing internal combustion machinery are to be provided with one of the fixed fire-extinguishing systems in 4.4.1.

4.5.2.2 *Additional fire-extinguishing arrangements* (Also refer MSC.1/Circ.1275 'Unified Interpretations of SOLAS Chapter II-2 on the Number and Arrangement of Portable Fire Extinguishers on Board Ships'.

4.5.2.2.1 There is to be at least one portable foam applicator unit complying with the provisions of the Fire Safety Systems Code.

4.5.2.2.2 There are to be in each such space approved foam type fire extinguishers each of at least 45 litres capacity or equivalent sufficient in number to enable foam or its equivalent to be directed onto any part of the fuel and lubricating oil pressure systems, gearing and other fire hazards. In addition, there is to be provided a sufficient number of portable foam extinguishers or equivalent which are to be so located that an extinguisher is not more than 10 [m] walking distance from any point in the space; provided that there are to be at least two such extinguishers in each such space. For ships under 150 tons gross the provision of a 45 litre extinguisher may be waived.

Table 4.5.1 : Number of systems, appliances and extinguishers required by clauses 4.5.1 and 4.5.2

Systems, appliances & extinguishers Category A machinery spaces	Fixed fire extinguishing system	Portable foam applicator *1	Portable foam extingui-shers	Additional portable foam extingui-shers	135 l foam extingui-sher	45 l foam extingui-shers *2	Sand boxes *3
Pt.6, Ch.3, Clause nos.	4.5.1.1 4.5.2.1	4.5.1.2.1 4.5.2.2.1	4.5.1.2.2	4.5.2.2.2	4.5.1.2.2	4.5.2.2.2	4.5.1.2.3
Boiler room containing:							
Oil-fired boilers	1	1	2N	NA	1*4	-	N
Oil-fired boilers and oil fuel units	1	1	2N + 2	NA	1*4	-	N
Engine room containing:							
Oil fuel units only	1	-	2	NA	-	-	-
Internal combustion machinery	1	1	x		-	Y	-
Internal combustion machinery and oil fuel units	1	1	x		-	y	-
Combined engine / boiler room containing:							
Internal combustion machinery, oil fired boilers and oil fuel units	1	1	(2N + 2) or x whichever is greater		1*4	y*5	N

N = number of firing spaces.
"2N" means that two extinguishers are to be located in each firing space.

x = sufficient number, minimum two in each space, so located that there are at least one portable fire extinguisher within 10 m walking distance from any point.

y = sufficient number to enable foam to be directed onto any part of the fuel and lubricating oil pressure systems, gearing and other fire hazards.

Notes:

*1 : May be located at outside of the entrance to the room.

*2 : May be arranged outside of the space concerned for smaller spaces of cargo ships.

*3 : The amount of sand is to be at least 0.1 m3. A shovel is to be provided. Sand boxes may be substituted by approved portable fire extinguishers.

*4 : Not required for such spaces in cargo ships wherein all boilers contained therein are for domestic services and are less than 175 kW.

*5 : In case of machinery spaces containing both boilers and internal combustion engines (case not explicitly considered in Clause 4.5. Clauses 4.5.1 and 4.5.2 apply, with the exception that one of the foam fire extinguishers of at least 45 l capacity or equivalent (required by 4.5.2.2.2) may be omitted on the condition that the 135 l extinguisher (required by 4.5.1.2.2) can protect efficiently and readily the area covered by the 45 l extinguisher.

*6 Oil fired machinery other than boilers such as fired inert gas generators, incinerators and waste disposal units are to be considered the same as boiler in so far as the required number and type of fire fighting appliances are concerned.

4.5.3 Machinery spaces containing steam turbines or enclosed steam engines

4.5.3.1 *Fixed fire-extinguishing systems*

In spaces containing steam turbines or enclosed steam engines used for main propulsion or other purposes having in the aggregate a total output of not less than 375 [kW], one of the fire-extinguishing systems specified in 4.4.1 is to be provided if such spaces are periodically unattended.

4.5.3.2 *Additional fire-extinguishing arrangements*

4.5.3.2.1 There are to be approved foam fire extinguishers each of at least 45 *l* capacity or equivalent sufficient in number to enable foam or its equivalent to be directed on to any part of the pressure lubrication system, on to any part of the casings enclosing pressure lubricated parts of the turbines, engines or associated gearing, and any other fire hazards. However, such extinguishers are not required if protection, at least equivalent to that required by this subparagraph, is provided in such spaces by a fixed fire-extinguishing system fitted in compliance with 4.4.1.

4.5.3.2.2 There are to be a sufficient number of portable foam extinguishers or equivalent which are to be so located that no point in the space is more than 10 [m] walking distance from an extinguisher and that there are at least two such extinguishers in each such space, except that such extinguishers are not required in addition to any provided in compliance with 4.5.1.2.2. (Also refer MSC.1/Circ.1275 'Unified Interpretations of SOLAS Chapter II-2 on the Number and Arrangement of Portable Fire Extinguishers on Board Ships'.

4.5.4 Other machinery spaces

Where a fire hazard exists in any machinery space for which no specific provisions for fire-extinguishing appliances are prescribed in 4.5.1, 4.5.2 and 4.5.3, there are to be provided in, or adjacent to, that space such a number of approved portable fire extinguishers or other means of fire extinction according to fire hazard in each space. (Also refer MSC.1/Circ.1275 'Unified Interpretations of SOLAS Chapter II-2 on the Number and Arrangement of Portable Fire Extinguishers on Board Ships'.

4.5.5 Additional requirements for passenger ships

In passenger ships carrying more than 36 passengers, each machinery space of category A is to be provided with at least two water fog applicators consisting of a metal L-shaped pipe, the long limb being about 2 [m] in length capable of being fitted to a fire hose and the short limb being about 250 [mm] in length fitted with a fixed water fog nozzle or capable of being fitted with a water spray nozzle.

4.5.6 Fixed local application fire-fighting systems

4.5.6.1 Sub-section 4.5.6 applies to passenger ships of 500 gross tonnage and above and cargo ships of 2000 gross tonnage and above.

4.5.6.2 Machinery spaces of category A above 500 [m^3] in volume in addition to the fixed fire-extinguishing system required in 4.5.1.1 are to be protected by a type of fixed water-based or equivalent local application fire-fighting system approved by the National Statutory Authority. In the case of periodically unattended machinery spaces, the fire fighting system is to have both automatic and manual release capabilities. In the case of continuously manned machinery spaces, the fire-fighting system is only required to have a manual release capability. (Refer to the Revised Guidelines for the approval of fixed water-based local application fire-fighting systems for use in category A machinery spaces (MSC.1/Circ.1387) and Unified Interpretations of SOLAS Chapter II-2 (MSC.1/Circ.1276)).

IR4.5.6.2 The automatic release of fire extinguishing medium is to be activated by a detection system capable of reliably identifying the local zones. Means are to be provided to prevent accidental release.

IR4.5.6.2.1 If the system installed deviates from the arrangement approved in accordance with MSC.1/Circ.1387, then such arrangement is to additionally pass the fire test based on the scenarios specified in the circular.

4.5.6.3 Fixed local application fire-fighting systems are to protect areas such as the following without the necessity of engine shutdown, personnel evacuation, or sealing of the spaces:

.1a) the fire hazard portions of all internal combustion machinery for ships constructed on or after 01 July, 2014 and

b) the fire hazard portions of internal combustion machinery used for the ship's main propulsion and power generation for ships constructed before 01 July, 2014.

IR.1 In multi-engine installations at least two sections are to be arranged to cover all internal combustion machinery.

.2 boiler fronts;

IR.2 (Boiler fronts in this context mean the boiler burner locations irrespective of the boiler design).

.3 the fire hazard portions of incinerators; and

.4 purifiers for heated fuel oil.

IR.5 oil fired equipment such as inert gas generators and thermal oil heaters.

4.5.6.4 Activation of any local application system is to give a visual and distinct audible alarm in the protected space and at continuously manned stations. The alarm is to indicate the specific system activated. The system alarm requirements described within this subsection are in addition to, and not a substitute for, the detection and fire alarm system required elsewhere in this chapter.

IR4.5.6.4 The alarms may be grouped together with provision for indication of the activated zone. Such alarms and indications are to be provided in wheel house in addition to protected space and engine control room. Audible alarms may use a single tone.

4.6 Fire-extinguishing arrangements in control stations, accommodation and service spaces

4.6.1 Sprinkler and water spray systems in passenger ships

4.6.1.1 Passenger ships carrying more than 36 passengers are to be equipped with an automatic sprinkler, fire detection and fire alarm system of an approved type complying with the requirements of the Fire Safety Systems Code (Chapter 8) in all control stations, accommodation and service spaces, including corridors and stairways. Alternatively, control stations, where water may cause damage to essential equipment, may be fitted with an approved fixed fire-extinguishing system of another type. Spaces having little or no fire risk such as voids, public toilets, carbon dioxide rooms and similar spaces need not be fitted with an automatic sprinkler system.

4.6.1.2 In passenger ships carrying not more than 36 passengers, when a fixed smoke detection and fire alarm system complying with the provisions of the Fire Safety Systems Code (Chapter 8) is provided only in corridors, stairways and escape routes within accommodation spaces, an automatic sprinkler system is to be installed in accordance with 1.5.3.2.

4.6.1.3 A fixed pressure water-spraying fire extinguishing system complying with the provisions of Ch8 is to be installed on cabin balconies of ships to which requirement of Ch.2, 2.3.4 applies, if furniture and furnishings on such balconies are not as defined in Ch.1, 3.40 a), b), c), f) and g).

4.6.2 Sprinkler systems for cargo ships

In cargo ships in which method IIC specified in 3.2.3.1.1.2 is adopted, an automatic sprinkler, fire detection and fire alarm system is to be fitted in accordance with the requirements in 1.5.5.2.

4.6.3 Spaces containing flammable liquid

4.6.3.1 Paint lockers are to be protected by any one of the following systems :

.1 a carbon dioxide system, designed to give a minimum volume of free gas equal to 40% of the gross volume of the protected space;

.2 a dry powder system, designed for at least 0.5 [kg powder/m^3];

.3 a water spraying or sprinkler system, designed for 5 [l/m^2 min]. Water spraying systems may be connected to the fire main of the ship; or

.4 a system providing equivalent protection, as determined by IRS.

In any case, the system is to be operable from outside the protected space.

4.6.3.2 Flammable liquid lockers are to be protected by an appropriate fire-extinguishing arrangement approved by IRS.

4.6.3.3 For lockers of a deck area of less than 4 [m^2], which do not give access to accommodation spaces, a carbon dioxide portable fire extinguisher sized to provide a minimum volume of free gas equal to 40% of the gross volume of the space may be accepted in lieu of a fixed system. A discharge port is to be arranged in the locker to allow the discharge of the extinguisher without having to enter into the protected space. The required portable fire extinguisher is to be stowed adjacent to the port. Alternatively, a port or hose connection may be provided to facilitate the use of fire main water.

IR4.6.3.3 The requirements given in 4.6.3.2 and 4.6.3.3 are not considered applicable for cargo service spaces intended for the stowage of cargo samples, when such spaces are positioned within the cargo area onboard tankers.

4.6.4 Deep-fat cooking equipment

Deep-fat cooking equipment installed in enclosed spaces or on open decks is to be fitted with the following:

.1 an automatic or manual extinguishing system tested to a recognised international standard; (Refer to the recommendations by the International Organization for Standardization, in particular, Publication ISO 15371:2000 on *Fire-extinguishing systems for protection of galley deep-fat cooking equipmen*t);

.2 a primary and backup thermostat with an alarm to alert the operator in the event of failure of either thermostat;

.3 arrangements for automatically shutting off the electrical power upon activation of the extinguishing system;

.4 an alarm for indicating operation of the extinguishing system in the galley where the equipment is installed; and

.5 controls for manual operation of the extinguishing system which are clearly labelled for ready use by the crew.

4.7 Fire extinguishing arrangements in cargo spaces

4.7.1 Fixed gas fire-extinguishing systems for general cargo

4.7.1.1 Except as provided for in 4.7.2, the cargo spaces of passenger ships of 1,000 gross tonnage and upwards are to be protected by a fixed carbon dioxide or inert gas fire-extinguishing system complying with the provisions of the Fire Safety Systems Code (Chapter 8) or by a fixed high expansion foam fire-extinguishing system which gives equivalent protection.

4.7.1.2 Where a passenger ship is engaged on voyages of such short duration that it would be unreasonable to apply the requirements of 4.7.1.1 and also in ships of less than 1,000 gross tonnage, the fire extinguishing arrangements in cargo spaces will be specially considered, provided that the ship is fitted with steel hatch covers and effective means of closing all ventilators and other openings leading to the cargo spaces.

4.7.1.3 Except for ro-ro and vehicle spaces, cargo spaces on cargo ships of 2,000 gross tonnage and upwards are to be protected by a fixed carbon dioxide or inert gas fire-extinguishing system complying with the Fire Safety Systems Code (Chapter 8), or by a fire-extinguishing system which gives equivalent protection.

IR4.7.1.3 In addition, ships of less than 2,000 tons gross tonnage carrying petroleum products having a flash point exceeding 60°C (c.c. test) are also not required to be fitted with a fixed fire extinguishing system.

4.7.1.4 The requirements of 4.7.1.3 and 4.7.2 may be waived for cargo spaces of any cargo ship if constructed, and solely intended for, the carriage of ore, coal, grain, unseasoned timber, non-combustible cargoes or cargoes which constitute a low fire risk. Such exemptions may be granted only if the ship is fitted with steel hatch covers and effective means of closing ventilators and other openings leading to the cargo spaces. (Refer to the Code of Safe Practice for Solid Bulk Cargoes – Emergency Schedule B14, entry for coal and to the List of solid bulk cargoes which are non-combustible or constitute a low fire risk or for which a fixed gas fire-extinguishing system is ineffective (MSC/Circ.671)).

4.7.2 Fixed gas fire-extinguishing systems for dangerous goods

A ship engaged in the carriage of dangerous goods in any cargo spaces is to be provided with a fixed carbon dioxide or inert gas fire-extinguishing system complying with the provisions of the Fire Safety Systems Code or with a fire-extinguishing system which gives equivalent protection for the cargoes carried.

IR4.7.2.1 Water supplies defined in Ch.7, 2.3.1.2 are considered as equivalent protection for cargoes listed in Table 2 of MSC Circ.671.

IR4.7.2.2 Clause 4.7.2 applies to the following ships engaged in the carriage of dangerous goods:

.1 Passenger ships constructed on or after 1 September 1984; and

.2 Cargo ships of 500 gross tonnage and upwards constructed on or after 1 September 1984;

.3 Cargo ships of less than 500 gross tonnage are not subject to Clause 4.7.2 even when such ships are engaged in the carriage of dangerous goods and document of compliance are issued to such ships according to Pt.6, Ch.7, Cl.2.4.

4.7.3 Firefighting for ships constructed on or after 1 January 2016 designed to carry containers on or above the weather deck

4.7.3.1 Ships are to carry, in addition to the equipment and arrangements required by 4.1 and 4.2, at least one water mist lance.

4.7.3.1.1 The water mist lance is to consist of a tube with a piercing nozzle which is capable of penetrating a container wall and producing water mist inside a confined space (container, etc.) when connected to the fire main.

4.7.3.2 Ships designed to carry five or more tiers of containers on or above the weather deck are to carry, in addition to the requirements of paragraph 4.7.3.1, mobile water monitors* as follows:

(*Refer to the Guidelines for the design, performance, testing and approval of mobile water monitors used for the protection of on-deck cargo areas of ships designed and constructed to carry five or more tiers of containers on or above the weather deck (MSC.1/Circ.1472).)

> .1 ships with breadth less than 30 [m] at least two mobile water monitors; or
>
> .2 ships with breadth of 30 [m] or more: at least four mobile water monitors.

4.7.3.2.1 The mobile water monitors, all necessary hoses, fittings and required fixing hardware are to be kept ready for use in a location outside the cargo space area not likely to be cut-off in the event of a fire in the cargo spaces.

4.7.3.2.2 A sufficient number of fire hydrants are to be provided such that:

> .1 all provided mobile water monitors can be operated simultaneously for creating effective water barriers forward and aft of each container bay;
>
> .2 the two jets of water required by paragraph 4.2.1.5.1 can be supplied at the pressure required by paragraph 4.2.1.6; and
>
> .3 each of the required mobile water monitors can be supplied by separate hydrants at the pressure necessary to reach the top tier of containers on deck.

4.7.3.2.3 The mobile water monitors may be supplied by the fire main, provided the capacity of fire pumps and fire main diameter are adequate to simultaneously operate the mobile water monitors and two jets of water from fire hoses at the required pressure values. If carrying dangerous goods, the capacity of fire pumps and fire main diameter is also to comply with Pt 6, Ch 7, Sec 2, and 2.3.1.5 as far as applicable to on-deck cargo areas.

On board cargo ships designed to carry five or more tiers of containers on or above the weather deck, the total capacity of the emergency fire pump need not exceed 72 [m^3/hr].

4.7.3.2.4 The operational performance of each mobile water monitor is to be tested during initial survey on board the ship to the satisfaction of the Administration. The test is to verify that:

> .1 the mobile water monitor can be securely fixed to the ship structure ensuring safe and effective operation; and
>
> .2 the mobile water monitor jet reaches the top tier of containers with all required monitors and water jets from fire hoses operated simultaneously.

4.8 Cargo tank protection

4.8.1 Fixed deck foam systems

4.8.1.1 For tankers of 20,000 tonnes deadweight and upwards, a fixed deck foam system is to be provided in accordance with the Fire Safety Systems Code (Chapter 8). Other fixed installations if they afford equivalent protection may be accepted is lieu of above installations. The requirements for alternative fixed installations are to comply with 4.8.1.2.

4.8.1.2 To be considered equivalent, the system proposed in lieu of the deck foam system is to be capable of:

.1 extinguishing spill fires and also precluding ignition of spilled oil not yet ignited, and

.2 combating fires in ruptured tanks.

4.8.1.3 Tankers of less than 20,000 tonnes deadweight are to be provided with a deck foam system complying with the requirements of the Fire Safety Systems Code (Chapter 8).

IR4.8.1 Where an enclosed pipe trunk is situated within the cargo tanks deck area, the pipe trunk is to comply with following:

.1 it is to be protected by a fixed fire extinguishing system in accordance with 4.9. the extinguishing system is to be operated from a readily accessible position outside the pipe trunk;

.2 it is not considered as part of the cargo tanks deck area;

.3 the area of the pipe trunk need not be included in the calculation of the foam solution rate of supply for the deck foam system required by 4.8;

.4 it is to be adequately ventilated and protected in accordance with Pt.5, Ch.2, 6.4.3 and 6.4.4 and

.5 it is to contain no flammable gas sources other than pipes and flanges. If the pipe trunk contains any other source of flammable gas, i.e. valves and pumps, it is to be regarded as cargo pump room.

4.9 Protection of cargo pump rooms in tankers

4.9.1 Fixed fire-extinguishing systems

Each cargo pump-room in tankers of 500 gross tonnage and more is to be provided with one of the following fixed fire-extinguishing systems operated from a readily accessible position outside the pump-room. Cargo pump-rooms are to be provided with a system suitable for machinery spaces of category A.

4.9.1.1 A carbon dioxide system complying with the provisions the Fire Safety Systems Code (Chapter 8) and with the following:

.1 the alarms giving audible warning of the release of fire-extinguishing medium are to be safe for use in a flammable cargo vapour/air mixture; and

.2 a notice is to be exhibited at the controls stating that due to the electrostatic ignition hazard, the system is to be used only for fire extinguishing and not for inerting purposes.

4.9.1.2 A high-expansion foam system complying with the provisions of the Fire Safety Systems Code (Chapter 8), provided that the foam concentrate supply is suitable for extinguishing fires involving the cargoes carried.

4.9.1.3 A fixed pressure water-spraying system complying with the provisions of the Fire Safety Systems Code (Chapter 8).

4.9.2 Quantity of fire-extinguishing medium

Where the extinguishing medium used in the cargo pump-room system is also used in systems serving other spaces, the quantity of medium provided or its delivery rate need not be more than the maximum required for the largest compartment.

IR4.9.3 In addition, two portable foam extinguishers or equivalent are to be provided, one at the pumps and one at the pump room entrance. (Refer 4.2.1.1.1 of Chapter 8 for capacity of foam extinguishers).

IR4.9.4 In ships of less than 500 tons gross tonnage, the fire extinguishing arrangements will be specially considered in each case.

4.10 Fire -fighter's outfits

4.10.1 Types of fire-fighter's outfits

4.10.1.1 Fire-fighter's outfits are to comply with the Fire Safety Systems Code (Chapter 8), and

4.10.1.2 Self-contained compressed air breathing apparatus of fire-fighter's outfits are to comply with paragraph 3.2.1.2.2 of the fire safety systems code (Chapter 8) by 1 July 2019.

4.10.2 Number of fire-fighter's outfits

4.10.2.1 Ships are to carry at least two fire-fighter's outfits.

4.10.2.2 In addition, in passenger ships there are to be provided:

.1 for every 80 [m], or part thereof, of the aggregate of the lengths of all passenger spaces and service spaces on the deck which carries such spaces or, if there is more than one such deck, on the deck which has the largest aggregate of such lengths, two fire-fighter's outfits and two sets of personal equipment, each set comprising the items stipulated in the Fire Safety Systems Code (Chapter 8). In passenger ships carrying more than 36 passengers, two additional fire-fighter's outfits are to be provided for each main vertical zone. However, for stairway enclosures which constitute individual main vertical zones and for the main vertical zones in the fore or aft end of a ship which do not contain spaces of categories (6), (7), (8) or (12) defined in 3.2.2.3, no additional fire-fighter's outfits are required; and

.2 ships carrying more than 36 passengers, for each pair of breathing apparatus there is to be provided one water fog applicator which is to be stored adjacent to such apparatus.

4.10.2.3 In addition, in tankers, two fire-fighter's outfits are provided.

4.10.2.4 Additional sets of personal equipment and breathing apparatus may be required, having due regard to the size and type of the ship.

4.10.2.5 Two spare charges are to be provided for each required breathing apparatus. Passenger ships carrying not more than 36 passengers and cargo ships that are equipped with suitably located means for fully recharging the air cylinders free from contamination, need carry only one spare charge for each required apparatus. In passenger ships carrying more than 36 passengers, at least two spare charges for each breathing apparatus are to be provided.

4.10.2.6 Passenger ships carrying more than 36 passengers constructed on or after 1 July 2010 are to be fitted with a suitably located means for fully recharging breathing air cylinders, free from contamination. The means for recharging are to be either:

.1 breathing air compressors supplied from the main and emergency switchboard, or independently driven, with a minimum capacity of 60 l/min per required breathing apparatus, not to exceed 420 l/min; or

.2 self-contained high-pressure storage systems of suitable pressure to recharge the breathing apparatus used on board, with a capacity of at least 1,200 l per required breathing apparatus, not to exceed 50,000 l of free air.

4.10.3 Storage of fire-fighter's outfits

4.10.3.1 The fire-fighter's outfits or sets of personal equipment are to be kept ready for use in an easily accessible location that is permanently and clearly marked and, where more than one fire-fighter's outfit or more than one set of personal equipment is carried, they are to be stored in widely separated positions.

4.10.3.2 In passenger ships, at least two fire-fighter's outfits and, in addition, one set of personal equipment are to be available at any one position. At least two fire-fighter's outfits are to be stored in each main vertical zone.

4.10.4 Fire-fighter's communication

4.10.4.1 For ships constructed on or after 1 July 2014, a minimum of two exclusive two-way portable radiotelephone apparatus for each fire party for fire-fighter's communication shall be carried on board. Those two-way portable radiotelephone apparatus shall be of an explosion-proof type or intrinsically safe. Ships constructed before 1 July 2014 shall comply with the requirements of this paragraph not later than the first survey after 1 July 2018.

IR4.11 Ships not fitted with propelling machinery

A power pump or hand pump and fire hose and nozzle are to be fitted, having suction from the sea and capable of producing a jet of water on deck with a throw of not less than 6 [m].

Where oil fuel is used for generation of power, fire extinguishing appliances suitable for fighting oil fires are to be provided to the satisfaction of the Surveyors.

Additional fire extinguishing equipment may be required in accommodation spaces or cargo spaces depending upon the potential fire hazard afforded by the equipment and materials carried on in these spaces.

Section 5

Structural Integrity

5.1 Purpose

The purpose of this regulation is to maintain structural integrity of the ship preventing partial or whole collapse of the ship structures due to strength deterioration by heat. For this purpose, materials used in the ships' structure are to ensure that the structural integrity is not degraded due to fire.

5.2 Material of hull, superstructures, structural bulkheads, decks and deckhouses

The hull, superstructures, structural bulkheads, decks and deckhouses are to be constructed of steel or other equivalent material. For the purpose of applying the definition of steel or other equivalent material as given in Ch.1, 3.43 the "applicable fire exposure" is to be according to the integrity and insulation standards given in Table 3.1 to Table 3.4. For example, where divisions such as decks or sides and ends of deckhouses are permitted to have "B-0" fire integrity, the "applicable fire exposure" is to be half an hour.

5.3 Structure of aluminium alloy

Aluminium alloys will be specially considered giving due regard to the fire protection method adopted to ensure:

.1 the insulation of aluminium alloy components of 'A' or 'B' class divisions except structures, which in the opinion of IRS are non- load bearing, is to be such that the temperature of the structural core does not rise more than 200°C above the ambient temperature at any time during the applicable fire exposure to the standard fire test.

IR.1 If an aluminium deck is tested with insulation installed below the deck, then the result is to apply to decks which are bare on the top. Aluminium decks are not to be provided with deck coverings or insulation on the top unless tested with the deck covering or insulation included, to verify that the 200°C temperature of the aluminium is not exceeded.

.2 special attention is to be given to the insulation of aluminium alloy components of columns, stanchions and other structural members required to support lifeboat and liferaft stowage, launching and embarkation areas, and 'A' and 'B' class divisions to ensure:

.2.1 that for such members supporting lifeboat and liferaft areas and 'A' class divisions, the temperature rise limitation specified in (5.3.1) is to apply at the end of one hour, and

.2.2 that for such members required to support 'B' class divisions, the temperature rise limitation specified in (5.3.1) is to apply at the end of half an hour.

5.4 Machinery spaces of category A

5.4.1 Crowns and casings

Crowns and casings of machinery spaces of category A is to be of steel construction and are to be insulated as required by Table 3.5a and Table 3.7, as appropriate.

5.4.2 Floor plating

The floor plating of normal passageways in machinery spaces of category A are to be made of steel.

5.5 Materials of overboard fittings

Materials readily rendered ineffective by heat are not to be used for overboard scuppers, sanitary discharges and other outlets which are close to the waterline and where the failure of the material in the event of fire would give rise to danger of flooding.

5.6 Protection of cargo tank structure against pressure or vacuum in tankers

5.6.1 General

Refer Pt.5, Ch.2, 8.1.4a) and b) for venting of small and large volumes.

5.6.2 Openings for small flow by thermal variations

Refer Pt.5, Ch.2, 8.1.14a) and b).

5.6.3 Safety measures in cargo tanks

5.6.3.1 *Preventive measures against liquid rising in the venting system*

Refer Pt.5, Ch.2, 8.1.5.

5.6.3.2 *Secondary means for pressure/vacuum relief*

Refer Pt.5, Ch.2, 8.1.4 c).

5.6.3.3 *Bypasses in vent mains*

Refer Pt.5, Ch.2, 8.1.9.

5.6.3.4 *Pressure/vacuum-breaking devices*

Refer Pt.5, Ch.2, 8.2.4.

5.6.4 Size of vent outlets

Large volume vent outlets for cargo loading, discharging and ballasting required by 5.6.1 are to be designed as given in Pt.5, Ch.2, 8.1.10. The master is to provided with information as given in Pt.5, Ch.2, 8.1.15 e).

End of Chapter

Chapter 4

Escape

Contents

Section 1

Notification of Crew and Passengers

1.1 Purpose

The purpose of this section is to notify crew and passengers of a fire for safe evacuation. For this purpose, a general emergency alarm system and a public address system are to be provided.

1.2 General emergency alarm system

A general emergency alarm system is to be used for notifying crew and passengers of a fire.

1.3 Public address systems in passenger ships

A public address system or other effective means of communication are to be available throughout the accommodation and service spaces and control stations and open decks.

Section 2

Means of Escape

2.1 Purpose

2.1.1 The purpose of this regulation is to provide means of escape so that persons onboard can safely and swiftly escape to the lifeboat and liferaft embarkation deck. For this purpose, the following functional requirements are to be met:

.1 safe escape routes are to be provided;

.2 escape routes are to be maintained in a safe condition, clear of obstacles; and

.3 additional aids for escape are to be provided as necessary to ensure accessibility, clear marking, and adequate design for emergency situations.

IR2.1.1 To facilitate a swift and safe means of escape to the lifeboat and liferaft embarkation deck, the following provisions apply to overhead hatches fitted along the escape routes.

.1 the securing devices shall be of a type which can be opened from both sides;

.2 the maximum force needed to open the hatch cover should not exceed 150 N; and

.3 the use of a spring equalizing, counterbalance or other suitable device on the hinge side to reduce the force needed for opening is acceptable.

2.2 General requirements

2.2.1 Unless expressly provided otherwise in this section, at least two widely separated and ready means of escape are to be provided from all spaces or group of spaces.

2.2.2 Lifts are not to be considered as forming one of the means of escape as required by this section.

2.3 Means of escape from control stations, accommodation and service spaces

2.3.1 General requirements

2.3.1.1 Stairways and ladders are to be so arranged as to provide ready means of escape to the lifeboat and liferaft embarkation deck from passenger and crew accommodation spaces and from spaces in which the crew is normally employed, other than machinery spaces.

2.3.1.2 Unless expressly provided otherwise in this section, a corridor, lobby, or part of a corridor from which there is only one route of escape is to be prohibited. Dead-end corridors used in service areas which are necessary for the practical utility of the ship, such as fuel oil stations and athwartship supply corridors, may be permitted, provided such dead-end corridors are separated from crew accommodation areas and are inaccessible from passenger accommodation areas. Also, a part of a corridor that has a depth not exceeding its width is considered a recess or local extension and is permitted.

2.3.1.3 All stairways in accommodation and service spaces and control stations are to be of steel frame construction except where the use of other equivalent material is specially approved.

2.3.1.4 If a radiotelegraph station has no direct access to the open deck, two means of escape from or access to such station are to be provided, one of which may be a porthole or window of sufficient size.

2.3.1.5 Doors in escape routes are to, in general, open in-way of the direction of escape, except that:

.1 individual cabin doors may open into the cabins in order to avoid injury to persons in the corridor when the door is opened; and

.2 doors in vertical emergency escape trunks may open out of the trunk in order to permit the trunk to be used both for escape and for access.

2.3.2 Means of escape in passenger ships

2.3.2.1 *Escape from spaces below the bulkhead deck*

2.3.2.1.1 Below the bulkhead deck two means of escape, at least one of which is to be independent of watertight doors, are to be provided from each watertight compartment or similarly restricted space or group of spaces. Exceptionally, IRS may dispense with one of the means of escape for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors.

2.3.2.1.2 Where dispensation is given under the provisions of 2.3.2.1.1, this sole means of escape is to provide safe escape. However, stairways are not to be less than 800 [mm] in clear width with handrails on both sides.

2.3.2.2 *Escape from spaces above the bulkhead deck*

Above the bulkhead deck there are to be at least two means of escape from each main vertical zone or similarly restricted space or group of spaces, at least one of which is to give access to a stairway forming a vertical escape.

2.3.2.3 *Direct access to stairway enclosures*

Stairway enclosures in accommodation and service spaces are to have direct access from the corridors and be of a sufficient area to prevent congestion, having in view the number of persons likely to use them in an emergency. Within the perimeter of such stairway enclosures, only public toilets, lockers of non-combustible material providing storage for non-hazardous safety equipment and open information counters are permitted. Only corridors, lifts, public toilets, special category spaces and open ro-ro spaces to which any passengers carried can have access, other escape stairways required by 2.3.2.4.1 and external areas are permitted to have direct access to these stairway enclosures. Public spaces may also have direct access to stairway enclosures except for the backstage of a theatre. Small corridors or "lobbies" used to separate an enclosed stairway from galleys or main laundries may have direct access to the stairway provided they have a minimum deck area of 4.5 [m^2], a width of not less than 900 [mm] and contain a fire hose station.

2.3.2.4 *Details of means of escape*

2.3.2.4.1 At least one of the means of escape required by 2.3.2.1.1 and 2.3.2.2 is to consist of a readily accessible enclosed stairway, which will provide continuous fire shelter from the level of its origin to the appropriate lifeboat and liferaft embarkation decks, or to the uppermost weather deck if the embarkation deck does not extend to the main vertical zone being considered. In the latter case, direct access to the embarkation deck by way of external open stairways and passageways will be provided and will have emergency lighting and slip-free surfaces underfoot. Boundaries facing external open stairways and passageways forming part of an escape route and boundaries in such a position that their failure during a fire would impede escape to the embarkation deck is to have fire integrity, including insulation values, in accordance with Table 3.1 to Table 3.4 of Part 6, Chapter 3, as appropriate.

2.3.2.4.2 Protection of access from the stairway enclosures to the lifeboat and liferaft embarkation areas is to be provided either directly or through protected internal routes which have fire integrity and insulation values for stairway enclosures as determined by Table 3.1 to Table 3.4 of Part 6, Chapter 3, as appropriate.

2.3.2.4.3 Stairways serving only a space and a balcony in that space is not to be considered as forming one of the required means of escape.

2.3.2.4.4 Each level within an atrium is to have two means of escape, one of which will give direct access to an enclosed vertical means of escape meeting the requirements of 2.3.2.4.1.

2.3.2.4.5 The widths, number and continuity of escapes are to be in accordance with the requirements in the Fire Safety Systems Code (Chapter 8).

2.3.2.5 *Marking of escape routes*

2.3.2.5.1 In addition to the emergency lighting the means of escape, including stairways and exits, are to be marked by lighting or photo-luminescent strip indicators placed not more than 300 [mm] above the deck at all points of the escape route including angles and intersections. The marking is to enable passengers to identify the routes of escape and readily identify the escape exits. If electric illumination is used, it is to be supplied by the emergency source of power and it is to be so arranged that the failure of any single light or cut in a lighting strip will not result in the marking being ineffective. Additionally, escape route signs and fire equipment location markings is to be of photoluminescent material or marked by lighting. Such lighting or photoluminescent equipment are to be evaluated, tested and applied in accordance with the Fire Safety Systems Code.

2.3.2.5.2 In passenger ships carrying more than 36 passengers, the requirements of 2.3.2.5.1 are to also apply to the crew accommodation areas.

2.3.2.5.3 In lieu of the escape route lighting system required by 2.3.2.5.1, alternative evacuation guidance systems may be accepted if approved by IRS based on the guidelines developed by the IMO*.

* Refer to the functional requirements and performance standards for the assessment of evacuation guidance systems (MSC1/Circ.1167) and the interim guidelines for the testing, approval and maintenance of evacuation guidance systems used as an alternative to low-location lighting systems (MSC1/Circ.1168).

2.3.2.6 *Normally locked doors that form part of an escape route*

2.3.2.6.1 Cabin and stateroom doors are not to require keys to unlock them from inside the room. There are not to be any doors along any designated escape route which require keys to unlock them when moving in the direction of escape.

2.3.2.6.2 Escape doors from public spaces that are normally latched are to be fitted with a means of quick release. Such means are to consist of a door-latching mechanism incorporating a device that releases the latch upon the application of a force in the direction of escape flow. Quick release mechanisms is to be designed and installed to the satisfaction of IRS and in particular:

.1 consist of bars or panels, the actuating portion of which extends across at least one half of the width of the door leaf, at least 760 [mm] and not more than 1120 [mm] above the deck;

.2 cause the latch to release when a force not exceeding 67 [N] is applied; and

.3 not be equipped with any locking device, set screw or other arrangement that prevents the release of the latch when pressure is applied to the releasing device.

2.3.3 Means of escape in cargo ships

2.3.3.1 *General*

At all levels of accommodation there are to be provided at least two widely separated means of escape from each restricted space or group of spaces.

2.3.3.2 *Escape from spaces below the lowest open deck*

Below the lowest open deck the main means of escape are to be a stairway and the second escape may be a trunk or a stairway.

2.3.3.3 *Escape from spaces above the lowest open deck*

Above the lowest open deck the means of escape are to be stairways or doors to an open deck or a combination thereof.

IR2.3.3.3 The “lowest open deck” is to be a category (10) “Open deck” (as defined in Chapter 3, Section 3, Cl.3.2.3.3.2.2 and Cl.3.2.4.2.2.2) at the lowest height from baseline in way of accommodation spaces.

2.3.3.4 *Dead-end corridors*

No dead-end corridors having a length of more than 7 [m] will be accepted. A dead-end corridor is a corridor or part of the corridor from which there is only one escape route.

2.3.3.5 *Width and continuity of escape routes*

The width, number and continuity of escape routes are to be in accordance with the requirements in the Fire Safety Systems Code (Chapter 8).

2.3.3.6 *Dispensation from two means of escape*

Exceptionally, one of the means of escape may be dispensed with, for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors.

2.3.4 Emergency escape breathing devices*

(* Refer to the Guidelines for the performance, location, use and care of emergency escape breathing devices (MSC/Circ.849)).

2.3.4.1 Emergency escape breathing devices are to comply with the Fire Safety Systems Code (Chapter 8). Spare emergency escape breathing devices are to be kept onboard.

2.3.4.2 All ships are to carry at least two emergency escape breathing devices within accommodation spaces.

2.3.4.3 In passenger ships, at least two emergency escape breathing devices are to be carried in each main vertical zone.

2.3.4.4 In passenger ships carrying more than 36 passengers, two emergency escape breathing devices, in addition to those required in 2.3.4.3 above, are to be carried in each main vertical zone.

2.3.4.5 However, 2.3.4.3 and 2.3.4.4 do not apply to stairway enclosures which constitute individual main vertical zones and for the main vertical zones in the fore or aft end of a ship which do not contain spaces of categories (6), (7), (8) or (12) defined in Ch.3, 3.2.2.3.

2.4 Means of escape from machinery spaces

2.4.1 Means of escape on passenger ships

Means of escape from each machinery space in passenger ships are to comply with the following provisions.

2.4.1.1 *Escape from spaces below the bulkhead deck*

Where the space is below the bulkhead deck the two means of escape is to consist of either:

.1 two sets of steel ladders as widely separated as possible , leading to doors in the upper part of the space similarly separated and from which access is provided to the appropriate lifeboat and liferaft embarkation decks. One of these ladders are to be located within a protected enclosure that satisfies Ch.3, 3.2.2.3, category (2), or Ch.3, 3.2.2.4, category (4), as appropriate, from the lower part of the space it serves to a safe position outside the space. Self-closing fire doors of the same fire integrity standards are to be fitted in the enclosure. The ladder is to be fixed in such a way that heat is not transferred into the enclosure through non-insulated fixing points. The protected enclosure is to have minimum internal dimensions of at least 800 [mm] x 800 [mm], and is to have emergency lighting provisions; or

.2 one steel ladder leading to a door in the upper part of the space from which access is provided to the embarkation deck and additionally, in the lower part of the space and in a position well separated from the ladder referred to, a steel door capable of being operated from each side and which provides access to a safe escape route from the lower part of the space to the embarkation deck.

2.4.1.2 *Escape from spaces above the bulkhead deck*

Where the space is above the bulkhead deck, the two means of escape are to be as widely separated as possible and the doors leading from such means of escape are to be in a position from which access is provided to the appropriate lifeboat and liferaft embarkation decks. Where such means of escape require the use of ladders, these are to be of steel.

2.4.1.3 *Dispensation from two means of escape*

In a ship of less than 1,000 gross tonnage, one of the means of escape may be dispensed with due regard being paid to the width and disposition of the upper part of the space. In a ship of 1,000 gross tonnage and above, one means of escape from any such space, including a normally unattended auxiliary machinery space may be dispensed with, so long as either a door or a steel ladder provides a safe escape route to the embarkation deck, due regard being paid to the nature and location of the space and whether persons are normally employed in that space. In the steering gear space, a second means of escape is to be provided when the emergency steering position is located in that space unless there is direct access to the open deck.

IR2.4.1.3 The requirement of dispensing with second means of escape, in a ship of 1000 gross tonnage and above, as given in 2.4.1.3 applies only to auxiliary machinery spaces where persons are not normally employed.

2.4.1.4 *Escape from machinery control rooms*

Two means of escape are to be provided from a machinery control room located within a machinery space, at least one of which will provide continuous fire shelter to a safe position outside the machinery space.

IR2.4.1 The above clauses (2.4.1.1, 2.4.1.2 & 2.4.1.4) are to be interpreted as follows:

.1 A “safe position” can be any space, excluding lockers and storerooms irrespective of their area, cargo spaces and spaces where flammable liquids are stowed, but including special category spaces and ro-ro spaces, from which access is provided and maintained clear of obstacles to the embarkation decks (Cl. 2.4.1.1 and 2.4.1.4)

.2 Inclined ladders/stairways in machinery spaces being part of, or providing access to, escape routes but not located within a protected enclosure are not to have an inclination greater than 60° and are not to be less than 600 [mm] in clear width. Such requirement need not be applied to ladders/stairways not forming part of an escape route, only provided for access to equipment or components, or similar areas, from one of the main platforms or deck levels within such spaces (Cl. 2.4.1).

.3 Machinery spaces may include working platforms and passageways, or intermediate decks at more than one deck level. In such case, the lower part of the space is to be regarded as the lowest deck level, platform or passageway within the space. At deck levels, other than the lowest one, where only one means of escape other than the protected enclosure is provided, self-closing fire doors are to be fitted in the protected enclosure at that deck level. Smaller working platforms in-between deck levels, or only for access to equipment or components, need not be provided with two means of escape (Cl. 2.4.1.1).

.4 A protected enclosure providing escape from machinery spaces to an open deck may be fitted with a hatch as means of egress from the enclosure to the open deck. The hatch is to have minimum internal dimensions of 800 [mm] x 800 [mm] (Cl. 2.4.1.1.1).

.5 Internal dimensions are to be interpreted as clear width, so that a passage having diameter of 800 mm is available throughout the vertical enclosure, as shown in Figure 2.4.1.4.1, clear of ship’s structure, with insulation and equipment, if any. The ladder within the enclosure can be included in the internal dimensions of the enclosure. When protected enclosures include horizontal portions their clear width is not to be less than 600 [mm]. Figure 2.4.1.4.1 is given as example of some possible arrangements which may be in line with the above interpretation (Cl. 2.4.1.1.1).

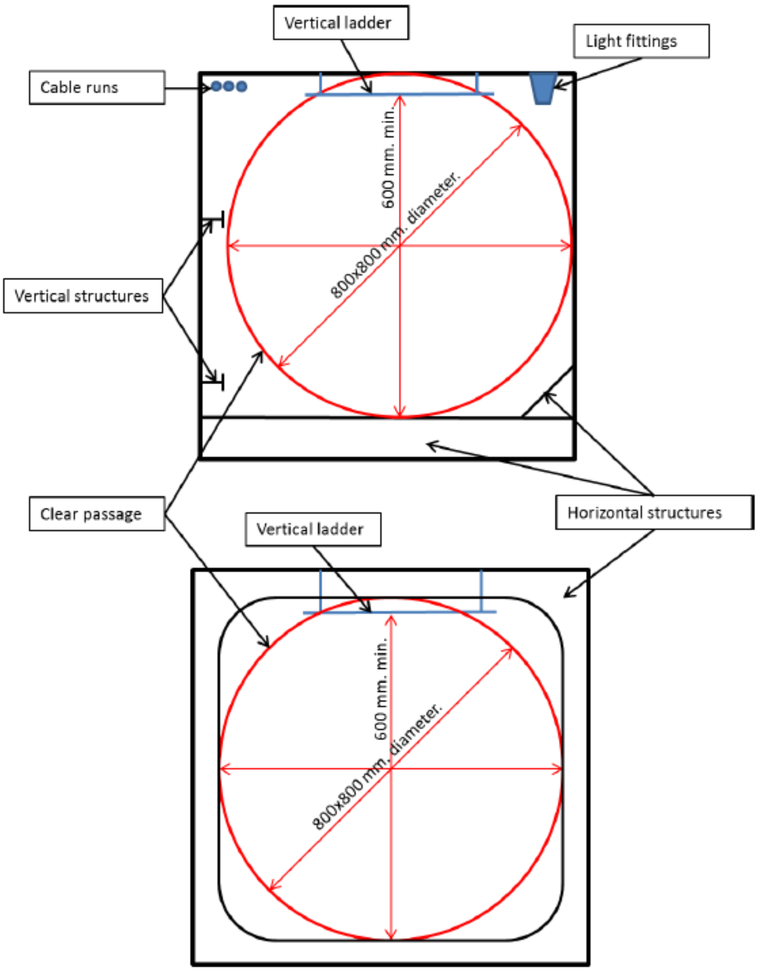


Fig.2.4.1.4.1 : Interpretation of Internal Dimensions – Possible Arrangements

2.4.1.5 *Inclined ladders and stairways*

All inclined ladders/stairways fitted to comply with 2.4.1.1 with open treads in machinery spaces being part of or providing access to escape routes but not located within a protected enclosure are to be made of steel. Such ladders/stairways are to be fitted with steel shields attached to their undersides, such as to provide escaping personnel protection against heat and flame from beneath.

2.4.1.6 *Escape from main workshops within machinery spaces*

Two means of escape are to be provided from the main workshop within a machinery space. At least one of these escape routes is to provide a continuous fire shelter to a safe position outside the machinery space.

2.4.2 Means of escape on cargo ships

Means of escape from each machinery space in cargo ships are to comply with the following provisions.

2.4.2.1 *Escape from machinery spaces of category A*

Except as provided in 2.4.2.2, two means of escape are to be provided from each machinery space of category A. In particular, one of the following provisions is to be complied with:

.1 two sets of steel ladders as widely separated as possible leading to doors in the upper part of the space similarly separated and from which access is provided to the open deck. One of these ladders is to be located within a protected enclosure that satisfies Ch.3, 3.2.3.3, category (4), from the lower part of the space it serves to a safe position outside the space. Self-closing fire doors of the same fire integrity standards are to be fitted in the enclosure. The ladder is to be fixed in such a way that heat is not transferred into the enclosure through non-insulated fixing points. The enclosure is to have minimum internal dimensions of at least 800 [mm] x 800 [mm], and is to have emergency lighting provisions; or

.2 one steel ladder leading to a door in the upper part of the space from which access is provided to the open deck and, additionally, in the lower part of the space and in a position well separated from the ladder referred to, a steel door capable of being operated from each side and which provides access to a safe escape route from the lower part of the space to the open deck.

2.4.2.2 *Dispensation from two means of escape*

In a ship of less than 1,000 gross tonnage, one of the means of escape required under 2.4.2.1 may be dispensed with, due regard being paid to the dimension and disposition of the upper part of the space. In addition, the means of escape from machinery spaces of category A need not comply with the requirement for an enclosed fire shelter listed in 2.4.2.1.1. In the steering gear space, a second means of escape is to be provided when the emergency steering position is located in that space unless there is direct access to the open deck.

IR2.4.2.2.1 Steering gear spaces which do not contain the emergency steering position need only have one means of escape.

.2 Steering gear spaces containing the emergency steering position can have one means of escape provided it leads directly onto the open deck. Otherwise, two means of escape are to be provided but they do not need to lead directly onto the open deck.

.3 Escape routes that pass only through stairways and/or corridors that have fire integrity protection equivalent to steering gear spaces are considered as providing a “direct access to the open deck”.

2.4.2.3 *Escape from machinery spaces other than those of category A*

From machinery spaces other than those of category A, two escape routes are to be provided except that a single escape route may be accepted for spaces that are entered only occasionally, and for spaces where the maximum travel distance to the door is 5 [m] or less.

IR2.4.2 The above clauses (2.4.2.1 & 2.4.2.3) are to be interpreted as follows:

.1 A “safe position” can be any space, excluding cargo spaces, lockers and storerooms irrespective of their area, cargo pump-rooms and spaces where flammable liquids are stowed, but including vehicle and ro-ro spaces, from which access is provided and maintained clear of obstacles to the open deck (Cl. 2.4.2.1.1).

.2 Inclined ladders/stairways in machinery spaces being part of, or providing access to, escape routes, but not located within a protected enclosure are not to have an inclination greater than 60° and are not to be less than 600 [mm] in clear width. Such requirement need not be applied to ladders/stairways not forming part of an escape route, only provided for access to equipment or components, or similar areas, from one of the main platforms or deck levels within such spaces (Cl. 2.4.2.1).

.3 Machinery spaces of category A may include working platforms and passageways, or intermediate decks at more than one deck level. In such case, the lower part of the space is to be regarded as the lowest deck level, platform or passageway within the space.
At deck levels, other than the lowest one, where only one means of escape other than the protected enclosure is provided, self-closing fire doors are to be fitted in the protected enclosure at that deck level. Smaller working platforms in-between deck levels, or only for access to equipment or components, need not be provided with two means of escape (Cl. 2.4.2.1).

.4 A protected enclosure providing escape from machinery spaces of category A to an open deck may be fitted with a hatch as means of egress from the enclosure to the open deck. The hatch is to have minimum internal dimensions of 800 [mm] x 800 [mm] (Cl. 2.4.2.1.1).

.5 Internal dimensions are to be interpreted as clear width, so that a passage having diameter of 800 [mm] is available throughout the vertical enclosure, as shown in Fig. 2.4.1.4.1, clear of ship’s structure, with insulation and equipment, if any. The ladder within the enclosure can be included in the internal dimensions of the enclosure. When protected enclosures include horizontal portions their clear width is not to be less than 600 [mm]. Figure 2.4.1.4.1 is given as an example of some possible arrangements which may be in line with the above interpretation (Cl. 2.4.2.1.1).

.6 In machinery spaces other than those of category A, which are not entered only occasionally, the travel distance is to be measured from any point normally accessible to the crew, taking into account machinery and equipment within the space (Cl. 2.4.2.3).

2.4.2.4 Inclined ladders and stairways

All inclined ladders/stairways fitted to comply with 2.4.2.1 with open treads in machinery spaces being part of or providing access to escape routes but not located within a protected enclosure are to be made of steel. Such ladders/stairways are to be fitted with steel shields attached to their undersides, such as to provide escaping personnel protection against heat and flame from beneath.

2.4.2.5 Escape from machinery control rooms in machinery spaces of category "A"

Two means of escape are to be provided from the machinery control room located within a machinery space. At least one of these escape routes is to provide a continuous fire shelter to a safe position outside the machinery space.

2.4.2.6 Escape from main workshops in machinery spaces of category "A"

Two means of escape are to be provided from the main workshop within a machinery space. At least one of these escape routes is to provide a continuous fire shelter to a safe position outside the machinery space.

2.4.3 Emergency escape breathing devices

2.4.3.1 On all ships, within the machinery spaces, emergency escape breathing devices are to be situated ready for use at easily visible places, which can be reached quickly and easily at any time in the event of fire. The location of emergency escape breathing devices is to take into account the layout of the machinery space and the number of persons normally working in the spaces. (Refer to the Guidelines for the performance, location, use and care of emergency escape breathing devices (MSC/Circ.849)).

2.4.3.2 The number and location of these devices are to be indicated in the fire control plan required in Ch.5, 2.2.4.

2.4.3.3 Emergency escape breathing devices are to comply with the Fire Safety Systems Code (Chapter 8).

2.5 Means of escape on passenger ships from special category and open ro-ro spaces to which any passengers carried can have access

2.5.1 In special category and open ro-ro spaces to which any passengers carried can have access, the number and locations of the means of escape both below and above the bulkhead deck are to be to the satisfaction of IRS and, in general, the safety of access to the embarkation deck is to be at least equivalent to that provided for under 2.3.2.1.1, 2.3.2.2, 2.3.2.4.1 and 2.3.2.4.2. Such spaces are to be provided with designated walkways to the means of escape with a breadth of at least 600 mm. The parking arrangements for the vehicles are to maintain the walkways clear at all times.

2.5.2 One of the escape routes from the machinery spaces where the crew is normally employed is to avoid direct access to any special category space.

2.6 Means of escape from ro-ro spaces

At least two means of escape are to be provided in ro-ro spaces where the crew are normally employed. The escape routes are to provide a safe escape to the lifeboat and liferaft embarkation decks and are to be located at the fore and aft ends of the space.

2.7 Additional requirements for ro-ro passenger ships

2.7.1 *General*

2.7.1.1 Escape routes are to be provided from every normally occupied space on the ship to an assembly station. These escape routes are to be arranged so as to provide the most direct route possible to the assembly station*, and are to be marked with symbols approved by the National Statutory Authority**.

(* Refer to the Indication of the "assembly stations" in passenger ships (MSC/Circ.777)).

(** Refer to the Symbols related to life-saving appliances and arrangements adopted by IMO by Resolution A.760(18)).

2.7.1.2 The escape route from cabins to stairway enclosures are to be as direct as possible, with a minimum number of changes in direction. It is not to be necessary to cross from one side of the ship to the other to reach an escape route. It is not to be necessary to climb more than two decks up or down in order to reach an assembly station or open deck from any passenger space.

2.7.1.3 External routes are to be provided from open decks, as referred to in 2.7.1.2, to the survival craft embarkation stations.

2.7.1.4 Where enclosed spaces adjoin an open deck, openings from the enclosed space to the open deck are, where practicable to be capable of being used as an emergency exit.

2.7.1.5 Escape routes are not to be obstructed by furniture and other obstructions. With the exception of tables and chairs which may be cleared to provide open space, cabinets and other heavy furnishings in public spaces and along escape routes are to be secured in place to prevent shifting if the ship rolls or lists. Floor coverings are also to be secured in place. When the ship is underway, escape routes are to be kept clear of obstructions such as cleaning carts, bedding, luggage and boxes of goods.

2.7.2 Instruction for safe escape

2.7.2.1 Decks are to be sequentially numbered, starting with "1" at the tank top or lowest deck. These numbers are to be prominently displayed at stair landings and lift lobbies. Decks may also be named, but the deck number is always to be displayed with the name.

2.7.2.2 Simple "mimic" plans showing the "you are here" position and escape routes marked by arrows, are to be prominently displayed on the inside of each cabin door and in public spaces. The plan is to show the directions of escape, and is to be properly oriented in relation to its position on the ship.

2.7.3 Strength of handrails and corridors

2.7.3.1 Handrails or other handholds are to be provided in all corridors along the entire escape route, so that a firm handhold is available at every step of the way, where possible, to the assembly stations and embarkation stations. Such handrails are to be provided on both sides of longitudinal corridors more than 1.8 [m] in width and transverse corridors more than 1 [m] in width. Particular attention is to be paid to the need to be able to cross lobbies, atriums and other large open spaces along escape routes. Handrails and other handholds are to be of such strength as to withstand a distributed horizontal load of 750 [N/m] applied in the direction of the centre of the corridor or space, and a distributed vertical load of 750 [N/m] applied in the downward direction. The two loads need not be applied simultaneously.

2.7.3.2 The lowest 0.5 [m] of bulkheads and other partitions forming vertical divisions along escape routes are to be able to sustain a load of 750 [N/m] to allow them to be used as walking surfaces from the side of the escape route with the ship at large angles of heel.

2.7.4 Evacuation analysis

(Refer to the Interim Guidelines for a simplified evacuation analysis of ro-ro passenger ships (MSC/Circ.909)).

Escape routes are to be evaluated by an evacuation analysis early in the design process. The analysis is to be used to identify and eliminate, as far as practicable, congestion which may develop during an abandonment, due to normal movement of passengers and crew along escape routes, including the possibility that crew may need to move along these routes in a direction opposite the movement of passengers. In addition, the analysis is to be used to demonstrate that escape arrangements are sufficiently flexible to provide for the possibility that certain escape routes, assembly stations, embarkation stations or survival craft may not be available as a result of a casualty.

End of Chapter

Chapter 5

Operational Requirements

Contents

Section 1

Operational Readiness and Maintenance

1.1 Purpose

The purpose of this section is to maintain and monitor the effectiveness of the fire safety measures the ship is provided with. For this purpose, the following functional requirements are to be met:

.1 fire protection systems and fire-fighting systems and appliances are to be maintained ready for use; and

.2 fire protection systems and fire-fighting systems and appliances are to be properly tested and inspected.

1.2 General requirements

At all times while the ship is in service, the requirements of 1.1.1 are to be complied with. A ship is not in service when:

.1 it is in for repairs or lay-up (either at anchor or in port) or in dry-dock;

.2 it is declared not in service by the owner or the owner’s representative; and

.3 in the case of passenger ships, there are no passengers on board. However, in this case, the vessel is to satisfy the requirements of 1.1.1 as for a cargo ship.

1.2.1 Operational readiness

1.2.1.1 The following fire protection systems are to be kept in good order so as to ensure their required performance if a fire occurs:

.1 structural fire protection including fire resisting divisions, and protection of openings and penetrations in these divisions;

.2 fire detection and fire alarm systems; and

.3 means of escape systems and appliances.

1.2.1.2 Fire-fighting systems and appliances are to be kept in good working order and readily available for immediate use. Portable extinguishers which have been discharged are to be immediately recharged or replaced with an equivalent unit.

1.2.2 Maintenance, testing and inspections

1.2.2.1 Maintenance, testing and inspections are to be carried out based on the requirements approved by the National Statutory Authority and in a manner having due regard to ensuring the reliability of fire-fighting systems and appliances. (Refer to the Guidelines on maintenance and inspection of fire protection systems and appliances (MSC/Circ.850)).

1.2.2.2 The maintenance plan is to be kept on board the ship and is to be available for inspection whenever required.

1.2.2.3 The maintenance plan is to include at least the following fire protection systems and fire-fighting systems and appliances, where installed:

.1 fire mains, fire pumps and hydrants including hoses, nozzles and international shore connections;

.2 fixed fire detection and fire alarm systems;

.3 fixed fire-extinguishing systems and other fire extinguishing appliances;

.4 automatic sprinkler, fire detection and fire alarm systems;

.5 ventilation systems including fire and smoke dampers, fans and their controls;

.6 emergency shut down of fuel supply;

.7 fire doors including their controls;

.8 general emergency alarm systems;

.9 emergency escape breathing devices;

.10 portable fire extinguishers including spare charges; and

.11 fire-fighter's outfits.

1.2.2.4 The maintenance programme may be computer-based.

1.3 Additional requirements for passenger ships

In addition to the fire protection systems and appliances listed in 1.2.2.3, ships carrying more than 36 passengers are to develop a maintenance plan for low-location lighting and public address systems.

1.4 Additional requirements for tankers

In addition to the fire protection systems and appliances listed in 1.2.2.3, tankers are to develop a maintenance plan for:

.1 inert gas systems;

.2 deck foam systems;

.3 fire safety arrangements in cargo pump rooms; and

.4 flammable gas detectors.

Section 2

Instructions, Onboard Training and Drills

2.1 Purpose

The purpose of this regulation is to mitigate the consequences of fire by means of proper instructions for training and drills of persons onboard in correct procedures under emergency conditions. For this purpose, the crew are to have the necessary knowledge and skills to handle fire emergency cases, including passenger care.

2.2 General requirements

2.2.1 Instructions, duties and organization

2.2.1.1 Crew members are to receive instruction on fire safety onboard the ship.

2.2.1.2 Crew members are to receive instructions on their assigned duties.

2.2.1.3 Parties responsible for fire-extinguishing are to be organized. These parties are to have the capability to complete their duties at all times while the ship is in service.

2.2.2 Onboard training and drills

2.2.2.1 Crew members are to be trained to be familiar with the arrangements of the ship as well as the location and operation of any fire-fighting systems and appliances that they may be called upon to use.

2.2.2.2 Training in the use of the emergency escape breathing devices is to be considered as part of on board training.

2.2.2.3 Performance of crew members assigned fire-fighting duties is to be periodically evaluated by conducting onboard training and drills to identify areas in need of improvement, to ensure competency in fire-fighting skills is maintained, and to ensure the operational readiness of the fire-fighting organization.

2.2.2.4 Onboard training in the use of the ship's fire-extinguishing systems and appliances is to be planned and conducted in accordance with provisions of SOLAS Reg. III/19.4.1.

2.2.2.5 Fire drills are to be conducted and recorded in accordance with the provisions of SOLAS Reg. III/19.3 and III/19.5.

2.2.2.6 An onboard means of recharging breathing apparatus cylinders used during drills shall be provided or a suitable number of spare cylinders shall be carried on board to replace those used.

2.2.3 Training manuals

2.2.3.1 A training manual is to be provided in each crew mess room and recreation room or in each crew cabin.

2.2.3.2 The training manual is to be written in the working language of the ship.

2.2.3.3 The training manual, which may comprise several volumes, is to contain the instructions and information required in 2.2.3.4 in easily understood terms and illustrated wherever possible. Any part of such information may be provided in the form of audio-visual aides in lieu of the manual.

2.2.3.4 The training manual is to explain the following in detail:

.1 general fire safety practice and precautions related to the dangers of smoking, electrical hazards, flammable liquids and similar common shipboard hazards;

.2 general instructions on fire-fighting activities and fire-fighting procedures including procedures for notification of a fire and use of manually operated call points;

.3 meanings of the ship’s alarms;

.4 operation and use of fire-fighting systems and appliances;

.5 operation and use of fire doors;

.6 operation and use of fire and smoke dampers; and

.7 escape systems and appliances.

2.2.4 Fire control plans

(Refer to the Graphical symbols for fire control plans, adopted by the Organization by resolution A.952(23)).

2.2.4.1 In all ships, fire control plans as given below are to be approved and permanently displayed for the guidance of ship's officers.

A general arrangement plan is to show clearly for each deck:

a) the control stations;

b) various fire sections enclosed by 'A' and 'B' class divisions together with particulars of fire detection and alarm systems;

c) the sprinkler installation;

d) the fire extinguishing appliances;

e) means of access to different compartments, etc.;

f) the ventilation system including particulars of the fan control positions, position of dampers and identification numbers of the ventilating fans serving each section.

Alternatively, the above mentioned details may be set out in a booklet, a copy of which is to be supplied to each officer, and at least one copy is to be available at all times on board in an accessible position.

Plans and booklets are to be kept up to date, any alterations being recorded thereon as soon as practicable. Description in such plans and booklets is to be in English and official language of the flag state.

2.2.4.2 A duplicate set of fire control plans or a booklet containing such plans is to be permanently stored in a prominently marked weathertight enclosure outside the deckhouse for the assistance of shore-side fire-fighting personnel. (Refer to the Guidance concerning the location of fire control plans for assistance of shoreside fire-fighting personnel (MSC/ Circ.451)).

2.3 Additional requirements for passenger ships

2.3.1 Fire drills

In addition to the requirement of 2.2.2.3, fire drills are to be conducted in accordance with the provision of SOLAS Reg.III/30 having due regard to notification of passengers and movement of passengers to assembly stations and embarkation decks.

2.3.2 Fire control plans

In ships carrying more than 36 passengers, plans and booklets required by this regulation is to provide information regarding fire protection, fire detection and fire extinction based on the requirements of the National Statutory Authority. (Refer to the Guidelines on the information to be provided with fire control plans and booklets required by SOLAS regulations II-2/20 and 41-2, adopted by the Organization by resolution A.756(18)).

Section 3

Operations

3.1 Purpose

The purpose of this regulation is to provide information and instructions for proper ship and cargo handling operations in relation to fire safety. For this purpose, the following functional requirements are to be met:

.1 fire safety operational booklets is to be provided on board; and

.2 flammable vapour releases from cargo tank venting is to be controlled.

3.2 Fire safety operational booklets

3.2.1 The required fire safety operational booklet is to contain the necessary information and instructions for the safe operation of the ship and cargo handling operations in relation to fire safety. The booklet is to include information concerning the crew's responsibilities for the general fire safety of the ship while loading and discharging cargo and while underway. Necessary fire safety precautions for handling general cargoes are to be explained. For ships carrying dangerous goods and flammable bulk cargoes, the fire safety operational booklet are also to provide reference to the pertinent fire-fighting and emergency cargo handling instructions contained in the International Maritime Solid Bulk Cargoes (IMSBC) Code the International Bulk Chemical Code, the International Gas Carrier Code and the International Maritime Dangerous Goods Code, as appropriate.

3.2.2 The fire safety operational booklet is to be provided in each crew mess room and recreation room or in each crew cabin.

3.2.3 The fire safety operational booklet is to be written in the working language of the ship.

3.2.4 The fire safety operational booklet may be combined with the training manuals required in 2.2.3.

3.3 Additional requirements for tankers

3.3.1 General

The fire safety operational booklet referred to in 3.2 is to include provisions for preventing fire spread to the cargo area due to ignition of flammable vapours and include procedures of cargo tank gas-purging and/or gas-freeing taking into account the provisions in 3.3.2.

3.3.2 Procedures for cargo tank purging and/or gas-freeing

3.3.2.1 When the ship is provided with an inert gas system, the cargo tanks are first to be purged in accordance with the provisions of Ch.2, 1.5.6 until the concentration of hydrocarbon vapours in the cargo tanks has been reduced to less than 2% by volume. Thereafter, gas-freeing may take place at the cargo tank deck level.

3.3.2.2 When the ship is not provided with an inert gas system, the operation is to be such that the flammable vapour is discharged initially through:

.1 the vent outlets as specified in Ch.2, 1.5.3.4;

.2 outlets at least 2 [m] above the cargo tank deck level with a vertical efflux velocity of at least 30 [m/s] maintained during the gas-freeing operation; or

.3 outlets at least 2 [m] above the cargo tank deck level with a vertical efflux velocity of at least 20 [m/s] and which are protected by suitable devices to prevent the passage of flame.

The above outlets are to be located not less than 10 [m] measured horizontally from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery, which may include anchor windlass and chain locker openings, and equipment which may constitute an ignition hazard.

When the flammable vapour concentration at the outlet has been reduced to 30% of the lower flammable limit, gas-freeing may be continued at cargo tank deck level.

3.3.3 Operation of inert gas system

3.3.3.1 The inert gas system for tankers required in accordance with Pt6, Ch2, 1.5.5.1 is to be so operated as to render and maintain the atmosphere of the cargo tanks non-flammable, except when such tanks are required to be gas-free.

3.3.3.2 Notwithstanding the above, for chemical tankers, the application of inert gas, may take place after the cargo tank has been loaded, but before commencement of unloading and shall continue to be applied until that cargo tank has been purged of all flammable vapours before gas-freeing. Only nitrogen is acceptable as inert gas under this provision.

3.3.3.3 Notwithstanding Pt 6, Ch 1, 1.3.2, the provisions of this paragraph shall only apply to tankers constructed on or after 1 January 2016. If the oxygen content of the inert gas exceeds 5% by volume, immediate action is to be taken to improve the gas quality. Unless the quality of the gas improves, all operations in those cargo tanks to which inert gas is being supplied are to be suspended so as to avoid air being drawn into the cargo tanks, the gas regulating valve, if fitted, is to be closed and the off-specification gas is to be vented to atmosphere.

3.3.3.4 In the event that the inert gas system is unable to meet the requirement in paragraph 3.3.3.1 and it has been assessed that it is impractical to effect a repair, then cargo discharge and cleaning of those cargo tanks requiring inerting shall only be resumed when suitable emergency procedures have been followed, taking into account guidelines developed by IMO*.

(*Refer to the *Clarification of inert gas system requirements under the Convention* (MSC/Circ.485) and to the *Revised Guidelines for inert gas systems* (MSC/Circ.353), as amended by MSC/Circ.387.)

End of Chapter

Chapter 6

Alternative Design and Arrangements

Contents

Section 1

Alternative Design and Arrangements

1.1 Purpose

The purpose of this section is to provide a methodology for alternative design and arrangements for fire safety.

1.2 General

1.2.1 Fire safety design and arrangements may deviate from the prescriptive requirements set out in Chapters 2, 3, 4, 5 or 7, provided that the design and arrangements meet the fire safety objectives and the functional requirements.

1.2.2 When fire safety design or arrangements deviate from the prescriptive requirements of this part, engineering analysis, evaluation and approval of the alternative design and arrangements are to be carried out in accordance with this section.

1.3 Engineering analysis

The engineering analysis is to be prepared and submitted to IRS (Refer to MSC/Circ.1002) and is to include, as a minimum, the following elements:

.1 determination of the ship type and space(s) concerned;

.2 identification of prescriptive requirement(s) with which the ship or the space(s) will not comply;

.3 identification of the fire and explosion hazards of the ship or the space(s) concerned;

.3.1 identification of the possible ignition sources;

.3.2 identification of the fire growth potential of each space concerned;

.3.3 identification of the smoke and toxic effluent generation potential for each space concerned;

.3.4 identification of the potential for the spread of fire, smoke or of toxic effluents from the space(s) concerned to other spaces;

.4 determination of the required fire safety performance criteria for the ships or the space(s) concerned addressed by the prescriptive requirement(s);

.4.1 performance criteria is to be based on the fire safety objectives and on the functional requirements of this part;

.4.2 performance criteria are to provide a degree of safety not less than that achieved by using the prescriptive requirements; and

.4.3 performance criteria is to be quantifiable and measurable;

.5 detailed description of the alternative design and arrangements, including a list of the assumptions used in the design and any proposed operational restrictions or conditions; and

.6 technical justification demonstrating that the alternative design and arrangements meet the required fire safety performance criteria.

1.4 Evaluation of the alternative design and arrangements

1.4.1 The engineering analysis required in 1.3 is to be evaluated and approved by IRS taking into account the requirements of the National Statutory Authority (Refer to MSC/Circ.1002).

1.4.2 A copy of the documentation, as approved by IRS, indicating that the alternative design and arrangements comply with this chapter is to be carried onboard the ship.

1.5 Exchange of information

Note : The Administration is to communicate to IMO pertinent information concerning alternative design and arrangements approved by them for circulation to all contracting governments.

1.6 Re-evaluation due to change of conditions

If the assumptions, and operational restrictions that were stipulated in the alternative design and arrangements are changed, the engineering analysis is to be carried out under the changed condition and is to be approved by IRS.

End of Chapter

Chapter 7

Special Requirements

Contents

Section 1

Helicopter Facilities

1.1 Purpose

The purpose of this section is to provide additional measures in order to address the fire safety objectives of this part for ships fitted with special facilities for helicopters. For this purpose, the following functional requirements are to be met:

.1 helideck structure is to be adequate to protect the ship from the fire hazards associated with helicopter operations;

.2 fire fighting appliances are to be provided to adequately protect the ship from the fire hazards associated with helicopter operations;

.3 refuelling and hangar facilities and operations are to provide the necessary measures to protect the ship from the fire hazards associated with helicopter operations; and

.4 operation manuals and training are to be provided.

1.2 Application

1.2.1 In addition to complying with the requirements of Chapters 2, 3, 4 and 5, as appropriate, ships equipped with helidecks are to comply with the requirements of this section.

1.2.2 Where helicopters land or conduct winching operations on an occasional or emergency basis on ships without helidecks, fire-fighting equipment fitted in accordance with the requirements in Ch.3 may be used. This equipment is to be made readily available in close proximity to the landing or winching areas during helicopter operations.

1.2.3 Notwithstanding the requirements of 1.2.2 above, ro-ro passenger ships without helidecks are to comply with SOLAS Reg.III/28.

1.3 Structure

1.3.1 Construction of steel or other equivalent material

In general, the construction of the helidecks is to be of steel or other equivalent materials. If the helideck forms the deckhead of a deckhouse or superstructure, it is to be insulated to "A-60" class standard.

1.3.2 Construction of aluminium or other low melting point metals

1.3.2.1 If helideck platform of such construction located above the ship's deckhouse or similar structure:

– The deckhouse top and bulkheads under the platform are to have no openings; and

– Windows under the platform are to be provided with steel shutters.

1.3.2.2 After each fire on the platform or in close proximity its suitability for further use will be specially considered in each case.

1.4 Means of escape

A helideck is to be provided with both a main and an emergency means of escape and access for fire fighting and rescue personnel. These are to be located as far apart from each other as is practicable and preferably on opposite sides of the helideck.

1.5 Fire-fighting appliances

1.5.1 In close proximity to the helideck, the following fire-fighting appliances are to be provided and stored near the means of access to that helideck (Also refer MSC.1/Circ.1275 'Unified Interpretations of SOLAS Chapter II-2 on the Number and Arrangement of Portable fire extinguishers on board ships'):

.1 at least two dry powder extinguishers having a total capacity of not less than 45 [kg];

.2 carbon dioxide extinguishers of a total capacity of not less than 18 [kg] or equivalent;

.3 a suitable foam application system consisting of monitors or foam making branch pipes capable of delivering foam to all parts of the helideck in all weather conditions in which helicopters can operate. The system is to be capable of delivering a discharge rate as required in Table 1.1 for at least five minutes;

Table 1.1 : Foam discharge rates

Category	Helicopter overall length	Discharge rate foam solution [l/min.]
H1	up to but not including 15 [m]	250
H2	from 15 [m] up to but not including 24 [m]	500
H3	from 24 [m] up to but not including 35 [m]	800

.4 the principal agent is to be suitable for use with salt water and conform to performance standards not inferior to those acceptable to the National Statutory Authority. (Refer to the International Civil Aviation Organization Airport Services Manual, Part 1 - Rescue and Fire fighting, Chapter 8 - Extinguishing Agent Characteristics, Paragraph 8.1.5 - Foam Specifications Table 8-1, Level 'B'));

.5 at least two nozzles of an approved dual-purpose type (jet/spray) and hoses sufficient to reach any part of the helideck;

.6 in addition to the requirements of Ch.3, 4.10, two sets of fire-fighter's outfits; and

.7 at least the following equipment are to be stored in a manner that provides for immediate use and protection from the elements:

- adjustable wrench;
- blanket, fire resistant;
- cutters, bolt 60 [cm];
- hook, grab or salving;
- hacksaw, heavy duty complete with 6 spare blades;
- ladder;
- lift line 5 [mm] diameter x 15 [m] in length;
- pliers, side cutting;
- set of assorted screwdrivers; and
- harness knife complete with sheath.

1.6 Drainage facilities

Drainage facilities in way of helidecks are to be constructed of steel and are to lead directly overboard independent of any other system and is to be designed so that drainage does not fall onto any part of the ship.

1.7 Helicopter refuelling and hangar facilities

Where the ship has helicopter refuelling and hangar facilities, the following requirements are to be complied with:

.1 a designated area is to be provided for the storage of fuel tanks which is to be:

.1.1 as remote as is practicable from accommodation spaces, escape routes and embarkation stations; and

.1.2 isolated from areas containing a source of vapour ignition;

.2 the fuel storage area is to be provided with arrangements whereby fuel spillage may be collected and drained to a safe location;

.3 tanks and associated equipment are to be protected against physical damage and from a fire in an adjacent space or area;

.4 where portable fuel storage tanks are used, special attention is to be given to:

.4.1 design of the tank for its intended purpose;

.4.2 mounting and securing arrangements;

.4.3 electric bonding; and

.4.4 inspection procedures;

.5 storage tank fuel pumps are to be provided with means which permit shutdown from a safe remote location in the event of a fire. Where a gravity fuelling system is installed, equivalent closing arrangements are to be provided to isolate the fuel source;

.6 the fuel pumping unit is to be connected to one tank at a time. The piping between the tank and the pumping unit is to be of steel or equivalent material, as short as possible, and protected against damage;

.7 electrical fuel pumping units and associated control equipment is to be of a type suitable for the location and potential hazards;

.8 fuel pumping units are to incorporate a device which will prevent over-pressurization of the delivery or filling hose;

.9 equipment used in refuelling operations is to be electrically bonded;

.10 "NO SMOKING" signs are to be displayed at appropriate locations;

.11 hangar, refuelling and maintenance facilities are to be treated as category ‘A’ machinery spaces with regard to structural fire protection, fixed fire-extinguishing and detection system requirements;

.12 enclosed hangar facilities or enclosed spaces containing refuelling installations are to be provided with mechanical ventilation, as required by 3.3 for closed ro-ro spaces of cargo ships. Ventilation fans are to be of non-sparking type; and

.13 electric equipment and wiring in enclosed hangar or enclosed spaces containing refuelling installations are to comply with 3.3.2, 3.3.3 and 3.3.4.

1.8 Operations manual and fire-fighting service

1.8.1 Each helicopter facility is to have an operations manual, including a description and a checklist of safety precautions, procedures and equipment requirements. This manual may be part of the ship’s emergency response procedures.

1.8.2 The procedures and precautions to be followed during refuelling operations are to be in accordance with recognized safe practices and contained in the operations manual.

1.8.3 Fire-fighting personnel consisting of at least two persons trained for rescue and fire-fighting duties and fire-fighting equipment are to be immediately available at all times when helicopter operations are expected.

1.8.4 Fire-fighting personnel are to be present during refuelling operations. However, the fire-fighting personnel are not to be involved with refuelling activities.

1.8.5 On-board refresher training is to be carried out and additional supplies of fire-fighting media is to be provided for training and testing of the equipment.

Section 2

Carriage of Dangerous Goods*

2.1 Purpose

The purpose of this section is to provide additional safety measures in order to address the fire safety objectives of this part for ships carrying dangerous goods. For this purpose, the following functional requirements are to be met:

.1 fire protection systems are to be provided to protect the ship from the added fire hazards associated with carriage of dangerous goods;

.2 dangerous goods are to be adequately separated from ignition sources; and

.3 appropriate personnel protective equipment are to be provided for the hazards associated with the carriage of dangerous goods.

2.2 General requirements

2.2.1 In addition to complying with the requirements of Chapters 2, 3, 4, 5 and sections 1 and 3**, as appropriate, ship types and cargo spaces, referred to in 2.2.2, intended for the carriage of dangerous goods are to comply with the requirements of this section, as appropriate, except when carrying dangerous goods in limited quantities*** and excepted quantities**** unless such requirements have already been met by compliance with the requirements elsewhere in this chapter. The types of ships and modes of carriage of dangerous goods are referred to in 2.2.2 and in Table 2.1. Cargo ships of less than 500 gross tonnage are to comply with this section, but Administrations may reduce the requirements and such reduced requirements are to be recorded in the document of compliance referred to in 2.4.

* Refer also to the Interim guidelines for open top containerships (MSC/Circ.608/Rev.1).

** Refer to part 7 of the International Maritime Dangerous Goods Code.

*** Refer to chapter 3.4 of the International Maritime Dangerous Goods Code.

**** Refer to chapter 3.5 of the IMDG Code.

2.2.2 The following ship types and cargo spaces are to govern the application of Table 2.1 and Table 2.2:

.1 ships and cargo spaces not specifically designed for the carriage of freight containers, but intended for the carriage of dangerous goods in packaged form including goods in freight containers and portable tanks;

.2 purpose-built container ships and cargo spaces intended for the carriage of dangerous goods in freight containers and portable tanks;

IR.2 A purpose built container space is a cargo space fitted with cell guides for stowage securing of containers.

.3 ro-ro ships and ro-ro spaces intended for the carriage of dangerous goods;

IR.3 Ro-ro spaces include special category spaces (refer section 3) and vehicle spaces (refer 2.3.2 and 2.3.3).

.4 ships and cargo spaces intended for the carriage of solid dangerous goods in bulk; and

.5 ships and cargo spaces intended for carriage of dangerous goods other than liquids and gases in bulk in shipborne barges.

2.3 Special requirements

Unless otherwise specified, the following requirements (2.3.1 to 2.3.10) are to govern the application of Table 2.1, Table 2.2 and Table 2.3 to both "on-deck" and "under-deck" stowage of dangerous goods where the numbers of the following paragraphs are indicated in the first column of the tables.

2.3.1 Water supplies

2.3.1.1 Arrangements are to be made to ensure immediate availability of a supply of water from the fire main at the required pressure either by permanent pressurization or by suitably placed remote arrangements for the fire pumps.

2.3.1.2 The quantity of water delivered is to be capable of supplying four nozzles of a size and at pressures as specified in Ch.3, 4.2, capable of being trained on any part of the cargo space when empty. The number and position of hydrants are to be such that at least two of the required four jets of water, when supplied by single lengths of hose, may reach any part of the cargo space when empty; and all four jets of water, each supplied by single lengths of hose may reach any part of ro-ro cargo spaces. This amount of water may be applied by equivalent means to the satisfaction of IRS.

2.3.1.3 Means of effectively cooling the designated underdeck cargo space by at least 5 l/min per square metre of the horizontal area of cargo spaces, either by a fixed arrangement of spraying nozzles or flooding the cargo space with water are to be provided. Hoses may be used for this purpose in small cargo spaces and in small areas of larger cargo spaces at the discretion of IRS. However, the drainage and pumping arrangements are to be such as to prevent the build-up of free surfaces. The drainage system is to be sized to remove no less than 125% of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles. The drainage system valves are to be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells are to be of sufficient holding capacity and are to be arranged at the side shell of the ship at a distance from each other of not more than 40 [m] in each watertight compartment. If this is not possible, the adverse effect upon stability of the added weight and free surface of water is to be taken into account to the extent deemed necessary during appraisal of stability information. (Refer to the Recommendation on fixed fire-extinguishing systems for special cargo spaces adopted by IMO by resolution A.123(V)).

2.3.1.4 Provision to flood a designated under-deck cargo space with suitable specified media may be substituted for the requirements in 3.1.3.

IR2.3.1.4 A high expansion foam system complying with Fire Safety Systems Code (Chapter 8) is acceptable except if cargoes dangerously react with water (see the IMDG Code, paragraph 16.2.2 of Section 16).

2.3.1.5 The total required capacity of the water supply is to satisfy 2.3.1.2 and 2.3.1.3, if applicable, simultaneously calculated for the largest designated cargo space. The capacity requirements of 2.3.1.2 are to be met by the total capacity of the main fire pump(s) not including the capacity of the emergency fire pump, if fitted. If a drencher system is used to satisfy 2.3.1.3, the drencher pump is also be taken into account in this total capacity calculation.

IR2.3.1.5 a) The water spray system required by paragraphs 9.2, 9.3 and 9.4 of MSC/Circ.608/ Rev.1 “Interim guidelines for open top container ships” will also satisfy the requirements for dangerous goods.

b) The amount of water required for fire fighting purposes in the largest hold is to allow simultaneous use of the water spray system plus the four jets of water from hose nozzles.

2.3.2 Sources of ignition

Electrical equipment and wiring is not to be fitted in enclosed cargo spaces or vehicle spaces unless it is considered essential for operational purposes. However, if electrical equipment is fitted in such spaces, it is to be of a certified safe type for use in the dangerous environments to which it may be exposed unless it is possible to completely isolate the electrical system (e.g. by removal of links in the system, other than fuses). Cable penetrations of the decks and bulkheads are to be sealed against the passage of gas or vapour. Through runs of cables and cables within the cargo spaces are to be protected against damage from impact. Any other equipment which may constitute a source of ignition of flammable vapour will not be permitted.

IR2.3.2 Notes for 2.3.2 :

1) Reference is to be made to IEC 60092-506 standard, Special features – Ships carrying specific dangerous goods and materials hazardous only in bulk.
2) For pipes having open ends (e.g. ventilation and bilge pipes, etc.) in a hazardous area, the pipe itself is to be classified as hazardous area. See IEC 60092-506 table B1, item B.
3) Enclosed spaces (e.g. pipe tunnels, bilge pump rooms, etc.) containing such pipes with equipment such as flanges, valves, pumps, etc. are to be regarded as an extended hazardous area, unless provided with overpressure in accordance with IEC 60092-506 clause 7.

2.3.3 Detection system

Ro-ro spaces are to be fitted with a fixed fire detection and fire alarm system complying with the requirements of the Fire Safety Systems Code (Chapter 8). All other types of cargo spaces are to be fitted with either a fixed fire detection and fire alarm system or a sample extraction smoke detection system complying with the requirements of the Fire Safety Systems Code. If a sample extraction smoke detection system is fitted, particular attention is to be made to the Fire Safety Systems Code (Chapter 8, Clause 10.2.1.3 in Sec.10) in order to prevent the leakage of toxic fumes into occupied areas.

2.3.4 Ventilation arrangement

2.3.4.1 Adequate power ventilation is to be provided in enclosed cargo spaces. The arrangement is to be such as to provide for at least six air changes per hour in the cargo space based on an empty cargo space and for removal of vapours from the upper or lower parts of the cargo space, as appropriate.

2.3.4.2 The fans are to be of non-sparking type, as per Pt.5, Ch.2, Cl.6.5. Suitable wire mesh guards are to be fitted over inlet and outlet ventilation openings to prevent foreign objects from entering into the fan casing.

2.3.4.3 Natural ventilation is to be provided in enclosed cargo spaces intended for the carriage of solid dangerous goods in bulk, where there is no provision for mechanical ventilation.

IR2.3.4.4 If adjacent spaces are not separated from cargo spaces by gastight bulkheads or decks, then they are considered as part of the enclosed cargo space and the ventilation requirements are to apply to the adjacent space as for the enclosed cargo space itself.

IR2.3.4.5 Where the IMSBC Code requires continuous ventilation in cargo holds, the ventilation openings are to comply with the requirements of Pt.3, Ch.13, Sec.2 for openings not fitted with means of closure. This does not prevent ventilators from being fitted with a means of closure as required for fire protection purposes as per Pt.6, Ch.2, Cl. 2.2.1.1 provided the minimum height to the ventilator opening is in accordance with Pt.3, Ch.13, Sec.2 (4.5.m for Position 1 and 2.3 m for Position 2).

The requirements for continuous ventilation apply to the following cargoes as per the IMSBC code:

ALUMINIUM FERROSILICON POWDER
UN 1395
ALUMINIUM SILICON POWDER, UNCOATED
UN 1398
ALUMINIUM SMELTING BY-PRODUCTS
or ALUMINIUM REMELTING BYPRODUCTS
UN 3170
FERROPHOSPHORUS (including
BRIQUETTES)
FERROSILICON (25% ≤ Silicon ≤ 30% or ≥ 90% Silicon)
FERROSILICON UN 1408 (30% ≤ Silicon < 90%)
ZINC ASHES UN 1435

IR2.3.4.6 Where two fans per hold are required in the IMSBC Code, a common ventilation system with two fans connected is acceptable.

IR2.3.4.7 For open top container holds, power ventilation is required only for the lower part of the cargo hold for which purpose ducting is required. The ventilation capacity is to be at least 2 air changes per hour based on the empty hold volume below weather deck.

2.3.5 Bilge pumping

2.3.5.1 Where it is intended to carry flammable or toxic liquids in enclosed cargo spaces, the bilge pumping system is to be designed to protect against inadvertent pumping of such liquids through machinery space piping or pumps. Where large quantities of such liquids are carried, consideration is to be given to the provision of additional means of draining those cargo spaces. These means are to be specially examined and approved.

2.3.5.2 If the bilge drainage system for cargo spaces is additional to the system served by pumps in the machinery space, the capacity of the system is to be not less than 10 [m^3/hr] per cargo space served. If the additional system is common, the capacity need not exceed 25 [m^3/h]. The additional bilge system need not be arranged with redundancy.

2.3.5.3 Whenever flammable or toxic liquids are carried, the bilge line into the machinery space is to be isolated either by fitting a blank flange or by a closed lockable valve.

2.3.5.4 Enclosed spaces outside of machinery spaces containing bilge pumps serving cargo spaces intended for carriage of flammable or toxic liquids are to be fitted with separate mechanical ventilation giving at least 6 airchanges per hour. Electrical equipment in the space is to be according to Pt.4, Ch.8. If the space has access from another enclosed space, the door is to be selfclosing.

IR2.3.5.4 Electrical equipment in the space is to be according to Pt.4, Ch.8.

2.3.5.5 If bilge drainage of cargo spaces is arranged by gravity drainage, the drainage is to be either led directly overboard or to a closed drain tank located outside the machinery spaces. The tank is to be provided with a vent pipe to a safe location on the open deck.

IR2.3.5.6 Cargo spaces intended for carriage of flammable liquids with flash point less than 23°C or toxic liquids are to be fitted with a fixed bilge drainage system independent or separated from the bilge system in machinery space and located outside of the machinery space.

If a single bilge drainage system completely independent of the machinery space is provided, the system is to comply with the Rule requirement to redundancy and capacity based on the size of the space or spaces which it serves.

IR2.3.5.7 Drainage from a cargo space into bilge wells in a lower space is only permitted if that space satisfies the same requirements as the cargo space above.

IR2.3.5.8 Bilge systems for open top container ship cargo holds are to be independent of machinery space bilge system and be located outside machinery space.

2.3.6 Personnel protection

2.3.6.1 Four sets of full protective clothing resistant to chemical attack are to be provided in addition to the fireman's outfits required by Ch.3, 4.10 and are to be selected taking into account the hazards associated with the chemicals being transported and the standards developed by IMO according to the class and physical state. (See Note 2 in IR2.3.6.1). The protective clothing is to cover all skin, so that no part of the body is unprotected.

IR2.3.6.1 Notes for 2.3.6.1:

1) The required protective clothing is for emergency purposes.

2) For solid bulk cargoes the protective clothing is to satisfy the equipment requirements specified in the respective schedules of the IMSBC Code for the individual substances. For packaged goods, the protective clothing is to satisfy the equipment requirements specified in emergency procedures (EmS) of the Supplement to IMDG Code for the individual substances

2.3.6.2 At least two self-contained breathing apparatuses additional to those required by Ch.3, Sec.4 is to be provided. Passenger ships carrying not more than 36 passengers and cargo ships that are equipped with suitably located means for fully recharging the air cylinders free from contamination, need carry only one spare charge for each required apparatus.

IR2.3.6.2 For each of the breathing apparatuses, two complete sets of air bottles are to be provided. These spare bottles are in addition to the spare bottles required for fire fighter’s outfit.

2.3.7 Portable fire extinguishers

Portable fire extinguishers with a total capacity of at least 12 [kg] of dry powder or equivalent are to be provided for the cargo spaces. These extinguishers are to be in addition to any portable fire extinguishers required elsewhere in this part. (Also refer MSC.1/Circ.1275 ‘Unified Interpretations of SOLAS Chapter II-2 on the Number and Arrangement of Portable fire extinguishers on board ships’)

2.3.8 Insulation of machinery space boundaries

Bulkheads forming boundaries between cargo spaces and machinery spaces of category A are to be insulated to "A-60" class standard, unless the dangerous goods are stowed at least 3 [m] horizontally away from such bulkheads. Other boundaries between such spaces are to be insulated to "A-60" class standard.

IR2.3.8 In the case of a closed or semi-closed cargo space located partly above a machinery space and the deck above the machinery space not insulated, dangerous goods are not to be carried in the whole of that cargo space. If un-insulated deck above the machinery space is a weather deck, dangerous goods are not to be carried in the portion of the deck above the machinery space.

2.3.9 Water spray system

Each open ro-ro space having a deck above it and each space deemed to be a closed ro-ro space not capable of being sealed, is to be fitted with an approved fixed pressure water-spraying system for manual operation which is to protect all parts of any deck and vehicle platform in the space. Use of any other fixed fire-extinguishing system that has been shown by full-scale test to be no less effective may be considered. However, the drainage and pumping arrangements are to be such as to prevent the build-up of free surfaces. The drainage system is to be sized to remove no less than 125% of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles. The drainage system valves are to be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells are to be of sufficient holding capacity and are to be arranged at the side shell of the ship at a distance from each other of not more than 40 [m] in each watertight compartment. If this is not possible the adverse effect upon stability of the added weight and free surface of water is to be taken into account during appraisal the stability information. (Refer to the Recommendation on fixed fire-extinguishing systems for special cargo spaces adopted by IMO by resolution A.123(V)).

2.3.10 Separation of ro-ro spaces

2.3.10.1 In ships having ro-ro spaces, a separation is to be provided between a closed ro-ro space and an adjacent open ro-ro space. The separation is to be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, such separation need not be provided if the ro-ro space is considered to be a closed cargo space over its entire length and is to fully comply with the relevant special requirements of this section.

2.3.10.2 In ships having ro-ro spaces, a separation is to be provided between a closed ro-ro space and the adjacent weather deck. The separation is to be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, a separation need not be provided if the arrangements of the closed ro-ro spaces are in accordance with those required for the dangerous goods carried on adjacent weather deck.

2.4 Document of compliance

(Refer to the Document of compliance with the special requirements for ships carrying dangerous goods under the provisions of regulation II-2/19 of SOLAS 74, as amended (MSC/Circ.1266)).

If requested and authorised by statutory authority IRS will provide the ship with an appropriate document as evidence of compliance of construction and equipment with the requirement of this section. Certification for carriage of solid dangerous bulk cargoes covers only those cargoes listed in Appendix B of the IMSBC Code except cargoes of MHB (Materials Hazardous only in Bulk) Other solid dangerous bulk cargoes may be certified subject to acceptance by the relevant statutory authority.

IR2.4 Notes regarding statutory document of compliance given in 2.4:

1) Ships constructed on or after 1 July 2002 are to comply with SOLAS Reg. II-2/19 and all the requirements introduced with 2000 SOLAS amendments and will be issued DoC in pursuance of regulation II-2/19.

2) Ships constructed on or after 1 July 1998 and before 1 July 2002 are to comply with SOLAS Reg. II-2/54 and all the requirements introduced with 1996 SOLAS amendments and will be issued DoC in pursuance of regulation II-2/54.

   (See Ch.1 Cl. 1.3.4 regarding retroactive application of SOLAS Reg.II-2/19 to such ships).

3) Ships constructed on or after 1 September 1984 and before 1 July 1998 are to comply with SOLAS Reg. II-2/54 and all the requirements introduced with 1981 SOLAS amendments and will be issued DoC in pursuance of regulation II-2/54.

   (See Ch.1 Cl. 1.3.4 regarding retroactive application of SOLAS Reg.II-2/19 to such ships).

4) Ships constructed before 1 September 1984, upon request of the Owner, will be issued DoC in pursuance of regulation II-2/54 provided they comply with the requirements of regulation II-2/54 and other regulations referred to in reg. II-2/54.

Table 2.1 : Application of the requirements to different modes of carriage of dangerous goods in ships and cargo spaces

Wherever X appears in Table 2.1 it means that this requirement is applicable to all classes of dangerous goods as given in the appropriate line of Table 2.3, except as indicated by the notes.

Clause 2.2.2		**.1**	**.2**	**.3**		**.4**	**.5**
Clause 2.3	**Weather decks .1 to .5 inclusive**	**Not specifi-cally designed**	**Container cargo spaces**	**Closed ro-ro cargo spaces[5]**	**Open ro-ro cargo spaces#**	**Solid dangerous goods in bulk**	**Shipbor-ne barges**
.1.1	X	X	X	X	X	For application of requirements of Sec.2 to different classes of dangerous goods, see Table 2.2	X
.1.2	X	X	X	X	X		-
.1.3	-	X	X	X	X		X
.1.4	-	X	X	X	X		X
.2	-	X	X	X	X		X[4]
.3	-	X	X	X	-		X[4]
.4.1	-	X	X[1]	X	-		X[4]
.4.2	-	X	X[1]	X	-		X[4]
.5	-	X	X	X	-		-
.6.1	X	X	X	X	X		-
.6.2	X	X	X	X	X		-
.7	X	X	-	-	X		-
.8	X	X	X[2]	X	X		-
.9	-	-	-	X[3]	X		-
.10.1	-	-	-	X	-		-
.10.2	-	-	-	X	-		-

Notes:

1 For classes 4 and 5.1 solids not applicable to closed freight containers.
For classes 2, 3, 6.1 and 8 when carried in closed freight containers, the ventilation rate may be reduced to not less than two air changes per hour. For classes 4 and 5.1 liquids when carried in closed freight containers, the ventilation rate may be reduced to not less than two air changes per hour. For the purpose of this requirement a portable tank is a closed freight container.

2 Applicable to decks only.

3 Applies only to closed ro-ro cargo spaces, not capable of being sealed.

4 In the special case where the barges are capable of containing flammable vapours or alternatively if they are capable of discharging flammable vapours to a safe space outside the barge carrier compartment by means of ventilation ducts connected to the barges, these requirements may be reduced or waived to the satisfaction of IRS.

5 Special category spaces are to be treated as closed ro-ro cargo spaces when dangerous goods are carried.

For the purposes of Section 5.6 a ro-ro space fully open above and with full openings in both ends may be treated as a weather deck.

Table 2.2 : Application of the requirements to different classes of dangerous goods for ships and cargo spaces carrying solid dangerous goods in bulk

Class*	**4.1**	**4.2**	**4.3**[6]	**5.1**	**6.1**	**8**	**9**
Clause							
2.3.1.1	X	X	-	X	-	-	X
2.3.1.2	X	X	-	X	-	-	X
2.3.2	X	X[7]	X	X[8]	-	-	X[8]
2.3.4.1	-	X[7]	X	-	-	-	-
2.3.4.2	X[9]	X[7]	X	X[7,9]	-	-	X[7,9]
2.3.4.3	X	X	X	X	X	X	X
2.3.6	X	X	X	X	X	X	X
2.3.8	X	X	X	X[7]	-	-	X[10]

* Classes are as defined in International Maritime Dangerous Goods Code.

Notes:

6 The hazards of substances in this class which may be carried in bulk are such that special consideration must be given by IRS to the construction and equipment of the ship involved in addition to meeting the requirements enumerated in this table.

7 Only applicable to –

- Seedcake containing solvent extractions
- Ammonium nitrate
- Ammonium nitrate fertilizers.

8 Only applicable to Ammonium nitrate and to Ammonium nitrate fertilizers. However, a degree of protection in accordance with standards contained in the International Electro-technical Commission, publication 60079 - Electrical Apparatus for Explosive Gas Atmospheres, is sufficient.

9 Only suitable wire mesh guards are required.

10 The requirements of the International Maritime Solid Bulk Cargoes (IMSBC) Code, as amended, are sufficient.

Table 2.3 : Application of the requirements to different classes of dangerous goods except solid dangerous goods in bulk

Clause Class*	1.1 to1 .6	1. 4 S	2.1	2.2	2.3 fla m ma ble[20]	2.3 no n- fla m ma ble	3 FP[15] < 23°C	3 FP[15] ≥ 23°C to ≤ 60°C	4.1	4.2	4.3 liquid s[21]	4.3 solid s	5.1	5.2[16]	6.1 liquid s FP[15] < 23°C	6.1 liquid s FP[15] ≥ 23°C to ≤ 60°C	6.1 liquid s	6.1 solid	8 liquid s FP[15] < 23°C	8 liquid s FP[15] ≥ 23°C to ≤ 60°C	8 liquid s	8 solid	9
2.3.1.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2.3.1.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-
2.3.1.3	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.3.1.4	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.3.2	X	-	X	-	X	-	X	-	-	-	X[18]	-	-	-	X	-	-	-	X	-	-	-	X[17]
2.3.3	X	X	X	X	-	X	X	X	X	X	X	X	X	-	X	X	X	X	X	X	X	X	-
2.3.4.1	-	-	X	-	-	X	X	-	X[11]	X[11]	X	X	X[11]	-	X	X	-	X[11]	X	X	-	-	X[11]
2.3.4.2	-	-	X	-	-	-	X	-	-	-	-	-	-	-	X	~~X~~ -	-	-	X	-	-	-	X[17]
2.3.5	-	-	-	-	-	-	X	-	-	-	-	-	-	-	X	X	X	-	X	X[19]	X[19]	-	-
2.3.6	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X[14]
2.3.7	-	-	-	-	-	-	X	X	X	X	X	X	X	-	X	X	-	-	X	X	-	-	-
2.3.8	X[12]	-	X	X	X	X	X	X	X	X	X	X	X[13]	X	X	X	-	-	X	X	-	-	-
2.3.9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2.3.10.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2.3.10.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

* Classes are as defined in International Maritime Dangerous Goods Code.

Table 2.3 - Notes:

11 When "mechanically ventilated spaces" are required by the International Maritime Dangerous Goods Code, as amended.

12 Stow 3 [m] horizontally away from the machinery space boundaries in all cases.

13 Refer to the International Maritime Dangerous Goods Code.

14 As appropriate to the goods being carried.

15 FP refers to flashpoint.

16 Under the provisions of the IMDG Code, stowage of class 5.2 dangerous goods under deck or in enclosed ro-ro spaces is prohibited.

17 Only applicable to dangerous goods evolving flammable vapour listed in the IMDG Code.

18 Only applicable to dangerous goods having a flashpoint less than 23°C listed in the IMDG Code.

19 Only applicable to dangerous goods having a subsidiary risk class 6.1.

20 Under the provisions of the IMDG Code, stowage of class 2.3 having subsidiary risk class 2.1 under deck or in enclosed ro-ro spaces is prohibited.

21 Under the provisions of the IMDG Code, stowage of class 4.3 liquids having a flashpoint less than 23°C under deck or in enclosed ro-ro spaces is prohibited.

Section 3

Protection of Vehicle, Special Category and Ro-ro Spaces

3.1 Purpose

The purpose of this section is to provide additional safety measures in order to address the fire safety objectives of this part for ships fitted with vehicle, special category and ro-ro spaces. For this purpose, the following functional requirements are to be met:

.1 fire protection systems are to be provided to adequately protect the ship from the fire hazards associated with vehicle, special category and ro-ro spaces;

.2 ignition sources are to be separated from vehicle, special category and ro-ro spaces; and

.3 vehicle, special category and ro-ro spaces are to be adequately ventilated.

3.2 General requirements

3.2.1 Application

In addition to complying with the requirements of Chapters 2, 3, 4 and 5, as appropriate, vehicle, special category and ro-ro spaces are to comply with the requirements of this section.

3.2.2 Basic principles for passenger ships

3.2.2.1 The basic principle underlying the provisions of this section is that the main vertical zoning required by Ch.3, 3.2 may not be practicable in vehicle spaces of passenger ships and, therefore, equivalent protection must be obtained in such spaces on the basis of a horizontal zone concept and by the provision of an efficient fixed fire-extinguishing system. Based on this concept, a horizontal zone for the purpose of these requirements may include special category spaces on more than one deck provided that the total overall clear height for vehicles does not exceed 10 [m]. The "Total overall clear height" is the sum of distances between deck and web frames of the decks forming one horizontal zone.

3.2.2.2 The basic principle underlying the provisions of 3.2.2.1 are also applicable to ro-ro spaces.

3.2.2.3 The requirements of ventilation systems, openings in "A" class divisions and penetrations in "A" class divisions for maintaining the integrity of vertical zones in this part are to be applied equally to decks and bulkheads forming the boundaries separating horizontal zones from each other and from the remainder of the ship.

3.3 Precaution against ignition of flammable vapours in closed vehicle spaces, closed ro-ro spaces and special category spaces

3.3.1 Ventilation systems

3.3.1.1 Capacity of ventilation systems

There are to be provided an effective power ventilation system sufficient to give at least the following air changes:

.1	Passenger ships	
	Special category spaces	10 air changes per hour
	Closed ro-ro and vehicle spaces other than special category spaces for ships carrying more than 36 passengers	10 air changes per hour
	Closed ro-ro and vehicle spaces other than special category spaces for ships carrying not more than 36 passengers	6 air changes per hour
.2	Cargo ships	6 air changes per hour

An increased number of air changes may be required when vehicles are being loaded and unloaded.

3.3.1.2 *Performance of ventilation systems*

3.3.1.2.1 In passenger ships, the power ventilation system required in 3.3.1.1 is to be separate from other ventilation systems and is to be in operation at all times when vehicles are in such spaces. Ventilation ducts serving such cargo spaces capable of being effectively sealed are to be separated for each such space. The system is to be capable of being controlled from a position outside such spaces.

3.3.1.2.2 In cargo ships, ventilation fans are to normally be run continuously whenever vehicles are on board. Where this is impracticable, they are to be operated for a limited period daily as weather permits and in any case for a reasonable period prior to discharge, after which period the ro-ro or vehicle space are to be proved gas-free. One or more portable combustible gas detecting instruments is to be carried for this purpose. The system is to be entirely separate from other ventilating systems. Ventilation ducts serving ro-ro or vehicle spaces are to be capable of being effectively sealed for each cargo space. The system is to be capable of being controlled from a position outside such spaces.

3.3.1.2.3 The ventilation system is to be such as to prevent air stratification and the formation of air pockets.

3.3.1.3 *Indication of ventilation systems*

Means is to be provided on the navigation bridge to indicate any loss of the required ventilating capacity.

IR3.3.1.3 Alarm provided on the bridge and initiated by tripping of starter relay of fan motor is considered to meet the requirement of 3.3.1.3.

3.3.1.4 *Closing appliances and ducts*

3.3.1.4.1 Arrangements are to be provided to permit a rapid shutdown and effective closure of the ventilation system from outside of the space in case of fire, taking into account the weather and sea conditions.

IR3.3.1.4.1 Access routes to the controls for closure of the ventilation system are considered to "permit a rapid shutdown" and adequately "take into account the weather and sea conditions" if the routes:
- are at least 600 mm clear width;
- are provided with a single handrail or wire rope lifeline not less than 10 mm in diameter, supported by stanchions not more than 10 m apart in way of any route which involves traversing a deck exposed to weather; and
- are fitted with appropriate means of access (such as ladders or steps) to the closing devices of ventilators located in high positions.

Alternatively, remote closing and position indicator arrangements from the bridge or a fire control station for those ventilator closures are considered acceptable.

3.3.1.4.2 Ventilation ducts, including dampers, within a common horizontal zone are to be made of steel. In passenger ships, ventilation ducts that pass through other horizontal zones or machinery spaces are to be “A-60” class steel ducts constructed in accordance with Ch.3, 3.7.2.4.1.1 and Ch.3, 3.7.2.4.1.2.

3.3.1.5 *Permanent openings*

Permanent openings in the side plating, the ends or deckhead of the space are to be so situated that a fire in the cargo space does not endanger stowage areas and embarkation stations for survival craft and accommodation spaces, service spaces and control stations in superstructures and deckhouses above the cargo spaces.

3.3.2 Electrical equipment and wiring

3.3.2.1 Except as provided in 3.3.2.2, electrical equipment and wiring are to be of a type suitable for use in an explosive petrol and air mixture.

IR3.3.2.1 Certified safe electrical equipment suitable for use in Zone 1 areas as defined in IEC publication 60079 (Gas Group IIA and Temperature class T3) is considered to satisfy the requirement given in 3.3.2.1. Refer IEC publication 60079 Part 14 for types of protection suitable for use in Zone 1 areas.

3.3.2.2 In case of other than special category spaces below the bulkhead deck, notwithstanding the provisions in 3.3.2.1, above a height of 450 [mm] from the deck and from each platform for vehicles, if fitted, except platforms with openings of sufficient size permitting penetration of petrol gases downwards, electrical equipment of a type so enclosed and protected as to prevent the escape of sparks will be permitted as an alternative on condition that the ventilation system is so designed and operated as to provide continuous ventilation of the cargo spaces at the rate of at least ten air changes per hour whenever vehicles are on board.

IR3.3.2.2 Electrical equipment provided with at least IP55 enclosure or suitable for use in Zone 2 areas as defined in IEC publication 60079 is considered to satisfy the requirement given in 3.3.2.2. Refer IEC publication 60079 Part 14 for types of protection suitable for use in Zone 2 areas.

3.3.3 Electrical equipment and wiring in exhaust ventilation ducts

Electrical equipment and wiring, if installed in an exhaust ventilation duct, is to be of a type approved for use in explosive petrol and air mixtures and the outlet from any exhaust duct is to be sited in a safe position, having regard to other possible sources of ignition.

IR3.3.3 Certified safe electrical equipment suitable for use in Zone 1 areas as defined in IEC publication 60079 (Gas Group IIA and Temperature class T3) is considered to satisfy the requirement given in 3.3.3. Refer IEC publication 60079 Part 14 for types of protection suitable for use in Zone 1 areas.

3.3.4 Other ignition sources

Other equipment which may constitute a source of ignition of flammable vapours will not be permitted.

3.3.5 Scuppers and discharges

Scuppers are not to be led to machinery or other spaces where sources of ignition may be present.

3.4 Detection and alarm

3.4.1 Fixed fire detection and fire alarm systems

Except as provided in 3.4.3.1, there is to be provided a fixed fire detection and fire alarm system complying with the requirements of the Fire Safety Systems Code (Chapter 8). The fixed fire detection system is to be capable of rapidly detecting the onset of fire. The type of detectors and their spacing and location is to be to the satisfaction of IRS taking into account the effects of ventilation and other relevant factors. After being installed the system is to be tested under normal ventilation conditions and is to give an overall response time to the satisfaction of IRS.

IR3.4.1 The requirement of 3.4.1 need not apply to weather decks used for the carriage of vehicle for fuel in their tanks.

3.4.2 Sample extraction smoke detection systems

Except open ro-ro spaces, open vehicle spaces and special category spaces, a sample extraction smoke detection system complying with the requirements of the Fire Safety Systems Code may be used as an alternative of the fixed fire detection and fire alarm system required in 3.4.1.

3.4.3 Special category spaces

3.4.3.1 An efficient fire patrol system is to be maintained in special category spaces. However, if an efficient fire patrol system is maintained by a continuous fire watch at all times during the voyage, a fixed fire detection and fire alarm systems is not required.

3.4.3.2 Manually operated call points are to be spaced so that no part of the space is more than 20 [m] from a manually operated call point, and one is to be placed close to each exit from such spaces.

3.5 Structural protection

Notwithstanding the provisions of Ch.3, 3.2.2, in passenger ships carrying more than 36 passengers, the boundary bulkheads and decks of special category spaces and ro-ro spaces are to be insulated to "A-60" class standard. However, where a category (5), (9) and (10) space, as defined in Ch.3, 3.2.2.3, is on one side of the division the standard may be reduced to "A-0". Where fuel oil tanks are below a special category space or a ro-ro space, the integrity of the deck between such spaces, may be reduced to "A-0" standard.

3.6 Fire-extinction

3.6.1 Fixed fire-extinguishing systems

(*The requirements of 3.6.1.1 and 3.6.1.2 apply to ships constructed on or after 1 July 2014. Ships constructed before 1 July 2014 are to comply with the previously applicable requirements of paragraphs 3.6.1.1 and 3.6.1.2)*

3.6.1.1 Vehicle spaces and ro-ro spaces which are not special category spaces and are capable of being sealed from a location outside of the cargo spaces are to be fitted with one of the following fixed fire-extinguishing systems:

.1 a fixed gas fire extinguishing system complying with the requirements of Chapter 8 ;

.2 a fixed high expansion foam fire-extinguishing system complying with the requirements of Chapter 8; or

.3 a fixed water-based fire fighting system for complying with the provisions of Ch 8, 7.2.4 and paragraphs 3.6.1.2.1 to 3.6.1.2.4.

3.6.1.2 Ro-ro and vehicle spaces not capable of being sealed and special category spaces are to be fitted with a fixed water-based fire fighting system complying with the requirements of Ch 8, 7.2.4, which will protect all parts of any deck and vehicle platform in such spaces.

Such a water-based fire-fighting system is to have:

.1 a pressure gauge on the valve manifold;

.2 clear marking on each manifold valve indicating the spaces served;

.3 instructions for maintenance and operation located in the valve room; and

.4 a sufficient number of drainage valves to ensure complete drainage of the system.

3.6.1.3 Use of any other fixed fire-extinguishing system may be permitted if it is shown that it is not less effective by a full-scale test in conditions simulating a flowing petrol fire in a vehicle space or a ro-ro space in controlling fires likely to occur in such a space. (Refer to the Revised Guidelines for the design and approval of fixed water-based fire-fighting systems for ro-ro spaces and special category spaces (MSC.1/Circ.1430)).

3.6.1.4 The requirements of this paragraph apply to ships constructed on or after 1 January 2010. Ships constructed on or after 1 July 2002 and before 1 January 2010 are to comply with the previously applicable version of this paragraph. When fixed pressure water-spraying systems are provided, in view of the serious loss of stability which could arise due to large quantities of water accumulating on the deck or decks during the operation of the fixed pressure water-spraying system, the following arrangements are to be provided:

.1 in passenger ships:

.1.1 in the spaces above the bulkhead deck, scuppers are to be fitted so as to ensure that such water is rapidly discharged directly overboard, taking into account MSC.1/ Circ.1320 “Guidelines for the drainage of fire-fighting water from closed vehicle and ro-ro spaces and special category spaces of passenger and cargo ships”;

.1.2.1 in ro-ro passenger ships discharge valves for scuppers, fitted with positive means of closing operable from a position above the bulkhead deck in accordance with the requirements of the International Convention on Load Lines in force, are to be kept open while the ships are at sea;

.1.2.2 any operation of valves referred to in 3.6.1.4.1.2.1 is to be recorded in the log-book;

.1.3 in the spaces below the bulkhead deck, IRS may require pumping and drainage facilities to be provided additional to the requirements of Pt.4, Ch.3, Sec.2. In such case, the drainage system is to be sized to remove no less than 125% of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles, taking into account MSC.1/Circ.1320 “Guidelines for the drainage of fire-fighting water from closed vehicle and ro-ro spaces and special category spaces of passenger and cargo ships”. The drainage system valves are to be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells are to be of sufficient holding capacity and are to be arranged at the side shell of the ship at a distance from each other of not more than 40 [m] in each watertight compartment;

.2 in cargo ships, the drainage and pumping arrangements are to be such as to prevent the build-up of free surfaces. In such case, the drainage system is to be sized to remove no less than 125% of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles, taking into account MSC.1/Circ.1320 “Guidelines for the drainage of fire-fighting water from closed vehicle and ro-ro spaces and special category spaces of passenger and cargo ships”. The drainage system valves are to be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells are to be of sufficient holding capacity and are to be arranged at the side shell of the ship at a distance from each other of not more than 40 [m] in each watertight compartment. If this is not possible the adverse effect upon stability of the added weight and free surface of water is to be taken into account to the extent deemed necessary. This information is to be included in the stability information supplied to the master.

3.6.1.5 On all ships, for closed vehicles and ro-ro spaces and special category spaces, where fixed pressure water-spraying systems are fitted, means shall be provided to prevent the blockage of drainage arrangements, taking into account MSC.1/Circ.1320 “Guidelines for the drainage of fire-fighting water from closed vehicle and ro-ro spaces and special category spaces of passenger and cargo ships”. Ships constructed before 1 January 2010 are to comply with the requirements of this paragraph by the first survey after 1 January 2010.

IR3.6.1.5 The requirements for fixed fire extinguishing system, portable fire extinguishers and foam applicators given in 3.6.1 and 3.6.2 need not apply to weather decks used for the carriage of vehicle with fuel in their tanks.

3.6.2 Portable fire extinguishers

3.6.2.1 Portable extinguishers are to be provided at each deck level in each hold or compartment where vehicles are carried, spaced not more than 20 [m] apart on both sides of the space. At least one portable fire-extinguisher is to be located at each access to such a cargo space. (Also refer MSC.1/Circ.1275 'Unified Interpretations of SOLAS Chapter II-2 on the Number and Arrangement of Portable fire extinguishers on board ships').

3.6.2.2 In addition to the provision of 3.6.2.1, the following fire extinguishing appliances are to be provided in vehicle, ro-ro and special category spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion:

.1 at least three water-fog applicators; and

.2 one portable foam applicator unit complying with the provisions of the Fire Safety Systems Code (Chapter 8), provided that at least two such units are available in the ship for use in such ro-ro spaces.

IR3.6.2.3 Also refer IR3.6.1.5.

IR3.6.2.4 Cargo holds, loaded with vehicles with fuel in their tanks and stowed in open or closed containers need not be provided with the portable fire extinguishers, water-fog applicators and foam applicator unit as given in 3.6.2.1 and 3.6.2.2.

Section 4

Requirements for vehicles carriers carrying as cargo motor vehicles with compressed hydrogen or natural gas in their tanks for their own propulsion

4.1 Purpose

4.1.1 The purpose of this section is to provide additional safety measures in order to address the fire safety objectives of this chapter for vehicle carriers with vehicle and ro-ro spaces intended for carriage as cargo motor vehicles with compressed hydrogen or compressed natural gas in their tanks for their own propulsion.

4.2 Application

4.2.1 In addition to complying with the requirements of section 3, as appropriate, vehicle spaces of vehicle carriers constructed on or after 1 January 2016 intended for the carriage as cargo motor vehicles with compressed hydrogen or compressed natural gas in their tanks for their own propulsion are to comply with the requirements given in this section.

4.2.2 In addition to complying with the requirements of Sec 3, as appropriate, vehicle carriers constructed before 1 January 2016, including those constructed before 1 July 2012*, are to comply with the requirements in 4.5 of this section.

(*Refer to the recommendation on safety ,measures for existing vehicle carriers carrying as cargo motor vehicles with compressed hydrogen or natural gas in their tanks for their own propulsion MSC.1/Circ.1471.)

4.3 Requirements for spaces intended for carriage of motor vehicles with compressed natural gas in their tanks for their own propulsion as cargo

4.3.1 Electrical equipment and wiring

All electrical equipment and wiring are tol be of a certified safe type for use in an explosive methane and air mixture*.

(* Refer to the recommendations of the International Electrotechnical Commission, in particular, publication IEC 60079)

4.3.2 Ventilation arrangement

4.3.2.1 Electrical equipment and wiring, if installed in any ventilation duct, are to be of a certified safe type for use in explosive methane and air mixtures.

4.3.2.2 The fans are to be such as to avoid the possibility of ignition of methane and air mixtures. Suitable wire mesh guards are to be fitted over inlet and outlet ventilation openings.

4.3.3 Other ignition sources

Other equipment which may constitute a source of ignition of methane and air mixtures are not to be permitted.

4.4 Requirements for spaces intended for carriage of motor vehicles with compressed hydrogen in their tanks for their own propulsion as cargo

4.4.1 Electrical equipment and wiring

All electrical equipment and wiring are to be of a certified safe type for use in an explosive hydrogen and air mixture*.

(*Refer to the recommendations of the International Electrotechnical Commission, in particular, publication IEC 60079.)

4.4.2 Ventilation arrangement

4.4.2.1 Electrical equipment and wiring, if installed in any ventilation duct, are to be of a certified safe type for use in explosive hydrogen and air mixtures and the outlet from any exhaust duct are to be sited in a safe position, having regard to other possible sources of ignition.

4.4.2.2 The fans are to be designed such as to avoid the possibility of ignition of hydrogen and air mixtures. Suitable wire mesh guards are to be fitted over inlet and outlet ventilation openings.

4.4.3 Other ignition sources

Other equipment which may constitute a source of ignition of hydrogen and air mixtures are not to be permitted.

4.5 Detection

When a vehicle carrier carries as cargo one or more motor vehicles with either compressed hydrogen or compressed natural gas in their tanks for their own propulsion, at least two portable gas detectors are to be provided. Such detectors are to be suitable for the detection of the gas fuel and be of a certified safe type for use in the explosive gas and air mixture.

Section 5

Casualty Threshold, Safe Return to Port and Safe Areas

5.1 Application

4.1.1 Passenger ships constructed on or after 1 July 2010 having loadline length, as defined in Pt.3, Ch.1, of 120 [m] or more or having three or more main vertical zones are to comply with the provisions of this section.

5.2 Purpose

5.2.1 The purpose of this section is to establish design criteria for a ship's safe return to port under its own propulsion after a casualty that does not exceed the casualty threshold stipulated in 5.3 and also provides functional requirements and performance standards for safe areas.

5.3 Casualty threshold

5.3.1 The casualty threshold, in the context of a fire, includes:

a) loss of space of origin upto the nearest "A" class boundaries, which may be a part of the space of origin, if the space of origin is protected by a fixed fire extinguishing system; or

b) loss of the space of origin and adjacent spaces upto the nearest "A" class boundaries, which are not part of the space of origin.

5.4 Safe return to port*

5.4.1 When fire damage does not exceed the casualty threshold indicated in 5.3, the ship is to be capable of returning to port while providing a safe area as defined in Ch.1, Sec.3. To be deemed capable of returning to port, the following systems are to remain operational in the remaining part of the ship not affected by fire:

- propulsion;
- steering systems and steering-control systems;
- navigational systems;

- systems for fill, transfer and service of fuel oil;
- internal communication between the bridge, engineering spaces, safety centre, fire-fighting and damage control teams and as required for passenger and crew notification and mustering;
- external communication;
- fire main system;
- fixed fire-extinguishing systems;
- fire and smoke detection system;
- bilge and ballast system;
- power-operated watertight and semi-watertight doors;
- systems intended to support "safe areas" as indicated in paragraph 4.5.1.2;
- flooding detection systems; and
- other systems determined by IRS to be vital to damage control efforts.

* Refer to MSC.1 Circ. 1369 "Interim explanatory notes for the assessment of passenger ship systems' capabilities after a fire or flooding casualty".

IR5.4.1 Qualitative failure analysis for propulsion and steering on passenger ships

IR5.4.1.1 Scope

This clause (IR 5.4.1) gives details of a qualitative failure analysis for propulsion and steering for new passenger ships including those having a length of 120 [m] or more or having three or more main vertical zones.

IR5.4.1.2 Note

This may be considered as the first step for demonstrating compliance with the revised SOLAS Chapter II-2, Regulation 21 – SOLAS 2006 Amendments, Resolution MSC.216(82), Annex 3.

IR5.4.1.3 Objectives

a) For ships having at least two independent means of propulsion and steering, to comply with SOLAS requirements for a safe return to port, items (a) and (b) below are applicable:

- Provide knowledge of the effects of failure in all the equipment and systems due to fire in any space, or flooding of any watertight compartment that could affect the availability of the propulsion and steering.
- Provide solutions to ensure the availability of propulsion and steering upon such failures in item (a).

b) Ships not required to satisfy the safe return to port concept will require the analysis of failure in single equipment and fire in any space to provide knowledge and possible solutions for enhancing availability of propulsion and steering.

IR5.4.1.4 Systems to be considered

The qualitative failure analysis is to consider the propulsion and steering equipment and all its associated systems which might impair the availability of propulsion and steering.

The qualitative failure analysis should include:

a) Propulsion and electrical power prime movers e.g.

- Diesel engines
- Electric motors

b) Power transmission systems, e.g.

- Shafting
- Bearings
- Power converters
- Transformers
- Slip ring systems

c) Steering gear

- Rudder actuator or equivalent for azimuthing propulsor
- Rudder stock with bearings and seals
- Rudder
- Power unit and control gear
- Local control systems and indicators
- Remote control systems and indicators
- Communication equipment

d) Propulsors, e.g.

- Propeller
- Azimuthing thruster
- Water jet

e) Main power supply systems, e.g.

- Electrical generators and distribution systems
- Cable runs
- Hydraulic
- Pneumatic

f) Essential auxiliary systems, e.g.

- Compressed air
- Oil fuel
- Lubricating oil
- Cooling water
- Ventilation
- Fuel storage and supply systems

g) Control and monitoring systems, e.g.

- Electrical auxiliary circuits
- Power supplies
- Protective safety systems
- Power management systems
- Automation and control systems

h) Support systems, e.g.

- Lighting
- Ventilation.

To consider the effects of fire or flooding in a single compartment, the analysis is to address the location and layout of equipment and systems.

IR5.4.1.5 Failure criteria

a) Failures are deviations from normal operating conditions such as loss or malfunction of a component or system such that it cannot perform an intended or required function.

b) The qualitative failure analysis is to be based on single failure criteria (not two independent failures occurring simultaneously).

c) Where a single failure causes results in failure of more than one component in a system (common cause failure), all the resulting failures are to be considered together.

d) Where the occurrence of a failure leads directly to further failures, all those failures are to be considered together.

IR5.4.1.6 Verification of solutions

a) The shipyard is to submit a report to IRS that identifies how the objectives have been addressed. The report is to include the following information:

- Identify the standards used for analysis of the design.
- Identify the objectives of the analysis.
- Identify any assumptions made in the analysis.
- Identify the equipment, system or sub-system, mode of operation of the equipment.
- Identify probable failure modes and acceptable deviations from the intended or required function.
- Evaluate the local effects (e.g. fuel injection failure) and the effects on the system as a whole (e.g. loss of propulsion power) of each failure mode as applicable.
- Identify trials and testing necessary to prove conclusions.

Note : All stakeholders (e.g. IRS, owners, shipyard and manufacturers) should as far as possible be involved in the development of the report.

b) The report is to be submitted prior to approval of detailed design plans. The report may be submitted in two parts:

- A preliminary analysis as soon as the initial arrangements of different compartments and propulsion plant are known which can form the basis of discussion. This is to include a structured assessment of all essential systems supporting the propulsion plant after a failure in equipment, fire or flooding in any compartment casualty.

- A final report detailing the final design with a detailed assessment of any critical system identified in the preliminary report.

c) Conclusions of the report are to be agreed between IRS and the shipyard.

5.5 Safe area(s)

5.5.1 Functional requirements:

a) the safe area(s) are generally to be internal space(s); however, the use of an external space as a safe area may be allowed by IRS taking into account any restriction due to the area of operation and relevant expected environmental conditions;

b) the safe area(s) are to provide all occupants with the following basic services* to ensure that the health of passengers and crew is maintained:

- sanitation;
- water;
- food;
- alternate space for medical care;
- shelter from the weather;
- means of preventing heat stress and hypothermia;
- light; and
- ventilation.

c) ventilation design is to reduce the risk of smoke and hot gases affecting the use of the safe area(s); and

d) means of access to life-saving appliances are to be provided from each area identified or used as a safe area, taking into account that a main vertical zone may not be available for internal transit.

* Refer to MSC.1 Circ. 1369 "Interim explanatory notes for the assessment of passenger ship systems' capabilities after a fire or flooding casualty".

5.5.2 Alternate space for medical care

Alternate space for medical care is to conform to a standard acceptable to IRS**.

** Refer to the Guidance on the establishment of medical and sanitation related programmes for passenger ships (MSC/Circ.1129).

Section 6

Design Criteria for Systems to Remain Operational after a Fire Casualty

6.1 Application

6.1.1 Passenger ships constructed on or after 1 July 2010 having loadline length, as defined in Pt.3, Ch.1, of 120 [m] or more or having three or more main vertical zones are to comply with the provisions of this section.

6.2 Purpose

6.2.1 The purpose of this regulation is to provide design criteria for systems required to remain operational for supporting the orderly evacuation and abandonment of a ship, if the casualty threshold, as defined in 5.3 is exceeded.

6.3 Systems*

6.3.1 In case any one main vertical zone is unserviceable due to fire, the following systems are to be so arranged and segregated as to remain operational:

- fire main;
- internal communications (in support of fire-fighting as required for passenger and crew notification and evacuation);
- means of external communications;
- bilge systems for removal of fire-fighting water;
- lighting along escape routes, at assembly stations and at embarkation stations of life-saving appliances; and
- guidance systems for evacuation are to be available.

* Refer to MSC.1 Circ. 1369 "Interim explanatory notes for the assessment of passenger ship systems' capabilities after a fire or flooding casualty".

6.3.2 The above systems are to be capable of operation for at least 3 hours based on the assumption of no damage outside the unserviceable main vertical zone. These systems are not required to remain operational within the unserviceable main vertical zones.

6.3.3 Cabling and piping within a trunk constructed to an "A-60" standard are deemed to remain intact and serviceable while passing through the unserviceable main vertical zone for the purposes of 6.3.1. An equivalent degree of protection for cabling and piping may be approved by IRS.

Section 7

Safety Centre on Passenger Ships

7.1 Application

7.1.1 Passenger ships constructed on or after 1 July 2010 are to have on board a safety centre complying with the requirements of this regulation.

7.2 Purpose

7.2.1 The purpose of this regulation is to provide a space to assist with the management of emergency situations.

7.3 Location and arrangement

7.3.1 The safety centre are either to be a part of the navigation bridge or be located in a separate space adjacent to and having direct access to the navigation bridge, so that the management of emergencies can be performed without distracting watch officers from their navigational duties.

7.4 Layout and ergonomic design

7.4.1 The layout and ergonomic design of the safety centre are to take into account the guidelines developed by IMO*, as appropriate.

* Refer to MSC.1 Circ. 1369 “Interim explanatory notes for the assessment of passenger ship systems’ capabilities after a fire or flooding casualty”.

7.5 Communications

7.5.1 Means of communication is to be provided between the safety centre, the central control station, the navigation bridge, the engine control room, the storage room(s) for fire extinguishing system(s) and fire equipment lockers.

7.6 Control and monitoring of safety systems

7.6.1 Notwithstanding the requirements set out elsewhere in the part of the rules, the full functionality (operation, control, monitoring or any combination thereof, as required) of the safety systems listed below shall be available from the safety centre:

- all powered ventilation systems;
- fire doors;
- general emergency alarm system;
- public address system;
- electrically powered evacuation guidance systems;
- watertight and semi-watertight doors;
- indicators for shell doors, loading doors and other closing appliances;
- water leakage of inner/outer bow doors, stern doors and any other shell door;
- television surveillance system;
- fire detection and alarm system;
- fixed fire-fighting local application system(s);
- sprinkler and equivalent systems;
- water-based systems for machinery spaces;
- alarm to summon the crew;
- atrium smoke extraction system;
- flooding detection systems; and
- fire pumps and emergency fire pumps.

End of Chapter

Chapter 8

Fire Safety Systems Code

Contents

Section

Preamble

1. The purpose of this Code is to provide international standards of specific engineering specifications for fire safety systems required by Chapter 1 to 7 of this part of rules.

2. This code will be applicable on or after 1 July 2002.

Section 1

General

1.1 Application

1.1.1 This chapter is applicable to fire safety systems as referred to in Chapters 1 to 7 of this part of Rules.

1.1.2 Unless expressly provided otherwise, this Chapter is applicable for the fire safety systems of ships the keels of which are laid or which are at a similar stage of construction on or after 1 July 2002. However, amendments to this chapter adopted after 1 July 2002 will apply only to ships the keels of which are laid or which are at a similar stage of construction, on or after the date on which the amendments enter into force, unless expressly provided otherwise.

1.2 Definitions

1.2.1 *Administration* means the Government of the State whose flag the ship is entitled to fly.

1.2.2 *Convention* means the International Convention for the Safety of Life at Sea, 1974, as amended.

1.2.3 *Fire Safety Systems Code (this chapter)* means the International Code for Fire Safety Systems as defined in Ch.1, 3.22.

1.2.4 For the purpose of this Chapter, definitions provided in Ch.1, Sec.3 also apply.

1.3 Use of equivalents and modern technology

In order to allow modern technology and development of fire safety systems, IRS may approve fire safety systems which are not specified in this Chapter if the requirements of Ch.6 are fulfilled.

1.4 Use of toxic extinguishing media

The use of a fire-extinguishing medium which either by itself or under expected conditions of use gives off toxic gases, liquids and other substances in such quantities as to endanger persons is not permitted.

Section 2

International Shore Connections

2.1 Application

This section details the specifications for international shore connections as required by Ch.3, 4.2.1.7.

2.2 Engineering specifications

2.2.1 Standard dimensions

The international shore connection is to be in accordance with the following specifications. (see Fig.2.1).

Standard dimensions of flanges for the international shore connection are to be in accordance with Table 2.1.

The flange is to have a flat face on one side and on the other side there is to be a permanently attached coupling that will fit the ships hydrants and hoses. The shore connection complete with gasket, four 16 [mm] bolts, 50 [mm] in length and 8 washers are to be stowed together in an easily accessible position along with other items of fire fighting outfit on board.

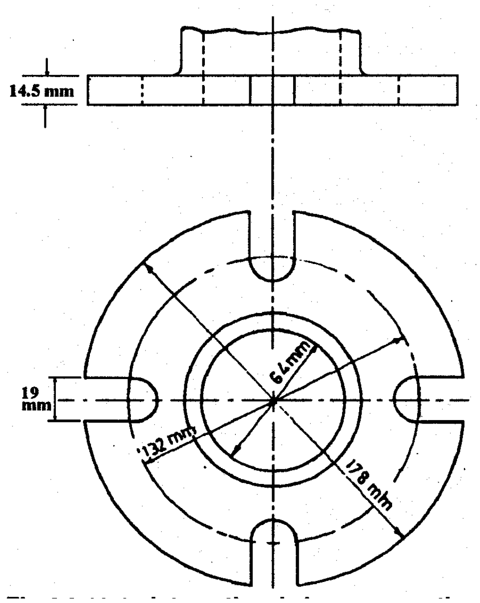


Fig.2.1 : International shore connection

Table 2.1 : Standard dimensions for international shore connections	
Description	**Dimension**
External diameter	178 [mm]
Internal diameter	64 [mm]
Bolt circle diameter	132 [mm]
Slots in flange	4 holes of 19 [mm] diameter equidistantly placed on the bolt circle, slotted to the flange periphery
Flange thickness	14.5 [mm] minimum
Bolts and nuts	4 each of 16 [mm] diameter, 50 [mm] in length
Material	steel or any other suitable material and designed for 1.0 [N/mm^2] service
Gasket Material	any material suitable for 1.0 [N/mm^2] pressure service

Section 3

Personnel Protection

3.1 Application

This section details the specifications for personnel protection as required by this part of the Rules.

3.2 Engineering specifications

3.2.1 Fire-fighter's outfit

A fire-fighter's outfit is to consist of a set of personal equipment and a breathing apparatus.

3.2.1.1 Personal equipment

Personal equipment is to consist of the following:

.1 protective clothing of material to protect the skin from the heat radiating from the fire and from burns and scalding by steam. The outer surface is to be water-resistant;

.2 boots of rubber or other electrically non-conducting material;

.3 rigid helmet providing effective protection against impact;

.4 electric safety lamp (hand lantern) of an approved type with a minimum burning period of 3 h. Electric safety lamps on tankers and those intended to be used in hazardous areas are to be of an explosion-proof type; and

.5 axe with a handle provided with high-voltage insulation.

3.2.1.2 Breathing apparatus

.1 Breathing apparatus is to be a self-contained compressed air-operated breathing apparatus for which the volume of air contained in the cylinders is to be at least 1,200 litres, or other self-contained breathing apparatus which is to be capable of functioning for at least 30 min. All air cylinders for breathing apparatus are to be interchangeable.

.2 Compressed air breathing apparatus is to be fitted with an audible alarm and a visual or other device which will alert the user before the volume of the air in the cylinder has been reduced to no less than 200 litres.

3.2.1.3 Lifeline

For each breathing apparatus a fireproof lifeline of at least 30 [m] in length is to be provided. The lifeline is to successfully pass an approval test by statical load of 3.5 [kN] for 5 min without failure. The lifeline is to be capable of being attached by means of a snap-hook to the harness of the apparatus or to a separate belt in order to prevent the breathing apparatus becoming detached when the lifeline is operated.

3.2.2 Emergency escape breathing devices (EEBD)

3.2.2.1 General

3.2.2.1.1 An EEBD is a supplied air or oxygen device only used for escape from a compartment that has a hazardous atmosphere and is to be of an approved type.

3.2.2.1.2 EEBDs are not to be used for fighting fires, entering oxygen deficient voids or tanks, or worn by fire-fighters. In these events, a self-contained breathing apparatus, which is specifically suited for such applications, are to be used.

3.2.2.2 Definitions

3.2.2.2.1 Face piece means a face covering that is designed to form a complete seal around the eyes, nose and mouth which is secured in position by a suitable means.

3.2.2.2.2 Hood means a head covering which completely covers the head, neck, and may cover portions of the shoulders.

3.2.2.2.3 Hazardous atmosphere means any atmosphere that is immediately dangerous to life or health.

3.2.2.3 Particulars

3.2.2.3.1 The EEBD are to have a service duration of at least 10 min.

3.2.2.3.2 The EEBD is to include a hood or full face piece, as appropriate, to protect the eyes, nose and mouth during escape. Hoods and face pieces are to be constructed of flame resistant materials and include a clear window for viewing.

3.2.2.3.3 An inactivated EEBD is to be capable of being carried hands-free.

3.2.2.3.4 An EEBD, when stored, is to be suitably protected from the environment.

3.2.2.3.5 Brief instructions or diagrams clearly illustrating their use is to be clearly printed on the EEBD. The donning procedures are to be quick and easy to allow for situations where there is little time to seek safety from a hazardous atmosphere.

3.2.2.4 Markings

Maintenance requirements, manufacturer's trademark and serial number, shelf life with accompanying manufacture date and name of approving authority are to be printed on each EEBD. All EEBD training units are to be clearly marked.

Section 4

Fire Extinguishers

4.1 Application

4.1.1 This section details the specifications for fire extinguishers as required by Ch.1 to 7.

4.1.2 Type approval

All fire extinguishers are to be of approved types and designs based on the requirements of the National Statutory Authority. (Refer to the Improved Guidelines for marine portable fire extinguishers adopted by IMO resolution A. 951(23)).

4.2 Engineering specifications

4.2.1 Fire extinguisher

4.2.1.1 Quantity of medium

4.2.1.1.1 Each powder or carbon dioxide extinguisher is to have a capacity of at least 5 [kg] and each foam extinguisher is to have a capacity of at least 9 [*l*]. The mass of all portable fire extinguishers is not to exceed 23 [kg] and they are to have a fire-extinguishing capability at least equivalent to that of a 9*l* fluid extinguisher.

4.2.1.2 Recharging

Only refills approved for the fire extinguisher in question is to be used for recharging.

4.2.2 Portable foam applicators

4.2.2.1 A portable foam applicator unit is to consist of foam nozzle/branch pipe, either of a self-inducting type or in combination with a separate inductor capable of being connected to the fire main by a fire hose together with a portable tank containing at least 20 litres of foam concentrate and at least one spare tank of foam concentrate of the same capacity.

4.2.2.2 System performance

4.2.2.2.1 The nozzle branch pipe and inductor are to be capable of producing effective foam suitable for extinguishing an oil fire at a foam solution flow rate of at least 200 l/min. at the nominal pressure in the fire main.

4.2.2.2.2 The foam concentrate is to be approved by IRS based on the guidelines developed by IMO (Guidelines for the performance and testing criteria and surveys of low-expansion foam concentrates for fixed fire extinguishing systems (MSC/Circ.582/Corr.1).

4.2.2.2.3 The values of the foam expansion and drainage time of the foam produced by the portable foam applicator unit is not to differ more than 10% of that determined in 4.2.2.2.2.

4.2.2.2.4 The portable foam applicator unit is to be designed to withstand clogging, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered on ships.

Section 5

Fixed Gas Fire-Extinguishing Systems

5.1 Application

This section details the specifications for fixed gas fire-extinguishing systems as required by Ch.3, Sec.4.

5.2 Engineering specifications

5.2.1 General

5.2.1.1 Fire-extinguishing medium

5.2.1.1.1 Where the quantity of the fire-extinguishing medium is required to protect more than one space, the quantity of medium available need not be more than the largest quantity required for any one space so protected. The system is to be fitted with normally closed control valves arranged to direct the medium into the appropriate space. Adjacent spaces with independent ventilation systems not separated by atleast A-0 class divisions are to be considered as the same space.

5.2.1.1.2 The volume of starting air receivers, converted to free air volume, is to be added to the gross volume of the machinery space when calculating the necessary quantity of the fire-extinguishing medium. Alternatively, a discharge pipe from the safety valves may be fitted and led directly to the open air.

5.2.1.1.3 Means are to be provided for the crew to safely check the quantity of the fire-extinguishing medium in the containers. It is not to be necessary to move the containers completely from their fixing position for this purpose. For carbon dioxide systems, hanging bars for a weighing device above each bottle row, or other means are to be provided. For other types of extinguishing media, suitable surface indicators may be used

5.2.1.1.4 Containers for the storage of fire-extinguishing medium and associated pressure components are to be designed to pressure codes of practice to the satisfaction of IRS having regard to their locations and maximum ambient temperature expected in service*.

* Publication ISO – 9809/1 : Refillable seamless steel gas cylinders (design, construction and testing);
ISO – 3500 : Seamless steel CO_2 cylinders. For fixed fire-fighting installations on ships, specifying the principal external dimensions, accessories, filling ratio and marking for seamless steel CO_2 cylinders used in fixed fire-fighting installations on ships, in order to facilitate their interchange ability;
ISO – 13769 : Gas cylinders – Stamp marking;
ISO – 6406 : Periodic inspection and testing of seamless steel gas cylinders.
ISO – 9329 Part 1 : Seamless steel tubes for pressure purpose – Technical delivery conditions – Part 1 – Unalloyed steels with specified room temperature properties;
ISO – 9329 Part 2 – Seamless steel tubes for pressure purposes – Technical delivery conditions – Part 2 – Unalloyed and alloyed steels with specified elevated temperature properties;
ISO – 9330 Part 1 – Welded steel tubes for pressure purposes – Technical delivery conditions – Part 1 – Unalloyed steel tubes with specified room temperature properties;
ISO 9330 Part 2 – Welded steel tubes for pressure purposes – Technical delivery conditions – Part 2 – Electric resistance and induction welded unalloyed and alloyed steel

tubes with specified elevated temperature properties.

5.2.1.2 Installation requirements

5.2.1.2.1 The piping for the distribution of fire-extinguishing medium is to be arranged and discharge nozzles so positioned that a uniform distribution of the medium is obtained. System flow calculations are to be performed to ensure uniform distribution and submitted for consideration of IRS.

5.2.1.2.2 Except as otherwise permitted by IRS, pressure containers required for the storage of fire-extinguishing medium, other than steam, is to be located outside the protected spaces in accordance with Ch.3, 4.4.3.

5.2.1.2.3 Sufficient spare parts for the system are to be stored on board, and the proposals, in each case, will be specially considered by IRS.

IR5.2.1.2.3 The piping is to be of adequate size and so arranged as to provide effective distribution of gas. In holds exceeding 18 [m] in length, there are to be at least two pipes, one of which is to be fitted in the forward part and one in the after part. Separate pipes are to be provided for lower hold and tween decks. All pipes are to be arranged to be self draining and are not to be led through refrigerated spaces unless the pipes are specially insulated.

5.2.1.2.4 In piping sections where valve arrangements introduce sections of closed piping, such sections are to be fitted with a pressure relief valve and the outlet of the valve is to be led to open deck.

IR5.2.1.2.4 Where carbon dioxide is used, all steel pipes are to be galvanized, at least internally.

5.2.1.2.5 All discharge piping, fittings and nozzles in the protected spaces are to be constructed of materials having a melting temperature which exceeds 925°C. The piping and associated equipment is to be adequately supported.

IR5.2.1.2.5 Distribution pipes are not to be smaller than 25 [mm] bore for inert gas and 20 [mm] bore for carbon dioxide.

5.2.1.2.6 A connection is to be installed in the discharge piping to permit the air testing as required by paragraph 5.2.2.3.1.

IR5.2.1.2.6 The minimum wall thicknesses of steel pipes of carbon dioxide systems are given in Table 5.2.1.2.5.

IR5.2.1.2.7 Slightly smaller thicknesses will be accepted where these meet recognized National Standards.

IR5.2.1.2.8 Where threaded pipes are used, the minimum wall thicknesses given in Table 5.2.1.2.5 are to be measured at the bottom of the thread.

IR5.2.1.2.9 For pipes of diameter larger than those shown in Table 5.2.1.2.5 the thickness will be specially considered.

Table 5.2.1.2.5 : Minimum thickness of steel pipes

External diameter D, [mm]	Thickness [mm]	
	From bottles to distribution valve	From distribution valve to nozzles
21.2 to 26.9	3.2	2.6
30.0 to 48.3	4.0	3.2
51.0 to 60.3	4.5	3.6
63.5 to 76.1	5.0	3.6
82.5 to 88.9	5.6	4.0
101.6	6.3	4.0
108.0 to 114.3	7.1	4.5
127.0	8.0	4.5
133.0 to 139.7	8.0	5.0
152.4 to 168.3	8.8	5.6

IR5.2.1.2.10 In general, the minimum thickness given in Table 5.2.1.2.5 is the nominal wall thickness, and no allowance need be made for negative tolerance and reduction in thickness due to bending.

IR5.2.1.2.11 For systems using carbon dioxide, the distribution manifolds and the pipes between the storage cylinders and the distribution valve are to be guaranteed by the manufacturers to have been satisfactorily hydraulically tested to a pressure of at least 12.2 [N/mm^2]. The manufacturers are to guarantee that at least 10 per cent of the pipes from the distribution valve to the discharge nozzles have been satisfactorily hydraulically tested to a pressure of at least 1.0 [N/mm^2]. On completion of the installation the joints are to be tested pneumatically to a pressure of atleast 0.69 [N/mm^2] with the discharge openings closed.

5.2.1.3 System control requirements

5.2.1.3.1 The necessary pipes for conveying fire-extinguishing medium into the protected spaces are to be provided with control valves so marked as to indicate clearly the spaces to which the pipes are led. Suitable provision is to be made to prevent inadvertent release of the medium into the space. Where a cargo space fitted with a gas fire-extinguishing system is used as a passenger space, the gas connection is to be blanked during such use. Blank flanges fitted in gas distribution pipes are to be of the 'spectacle' type. The nuts for the securing bolts are to be of non-corrodible metal. The pipes may pass through accommodations provided that they are of substantial thickness and that their tightness is verified with a pressure test, after their installation, at a pressure head not less than 5 [N/mm^2]. In addition, pipes passing through accommodation areas are to be joined only by welding and are not to be fitted with drains or other openings within such spaces. The pipes are not to pass through refrigerated spaces.

5.2.1.3.2 Means are to be provided for automatically giving audible and visual warning of the release of fire extinguishing medium into any ro-ro spaces, container holds equipped with integral reefer containers, spaces accessible by doors or hatches and other spaces in which personnel normally work or to which they have access. The audible alarms are to be located so as to be audible throughout the protected space with all machinery operating and the alarms are to be capable of being distinguished from other audible alarms by adjustment of sound pressure or sound patterns. The pre-discharge alarm is to be automatically activated (e.g. by opening of the release cabinet door). The alarm is to operate for the length of time needed to evacuate the space, but not less than 20 [s], before the medium is released. Conventional cargo spaces and small spaces (such as compressor rooms, paint lockers, etc.) with only a local release need not be provided with such alarm.

IR5.2.1.3.2 a) Reference is made to the Code on alerts and Indicators (AI Code), 1995 (Resolution A.1021(26)).

IR5.2.1.3.2 b) Conventional cargo spaces means cargo spaces other than ro-ro spaces or container holds equipped with integral reefer containers, and they need not be provided with means for automatically giving audible and visual warning of the release.

IR5.2.1.3.2 c) The requirements mentioned in 5.2.2.2 are also applicable for the spaces mentioned in 5.2.1.3.2.

5.2.1.3.3 The means of control of any fixed gas fire-extinguishing system are to be readily accessible, simple to operate and are to be grouped together in as few locations as possible at positions not likely to be cut off by a fire in a protected space. At each location there are to be clear instructions relating to the operation of the system having regard to the safety of personnel.

IR5.2.1.3.3 For control of fixed gas fire extinguishing media stored in a room located forward of cargo holds and intended for protecting cargo holds, refer Ch.3, IR4.4.3.

5.2.1.3.4 Automatic release of fire-extinguishing medium is not to be permitted, except as permitted by IRS.

IR5.2.1.4 Alarms in pump room.

IR5.2.1.4.1 The audible alarms fitted in cargo pump rooms of ships intended for the carriage of cargo oil having a flash point below 60°C (closed cup test), to warn of the release of extinguishing medium in such spaces, may be of the pneumatic or electrical type.

IR5.2.1.4.2 Where pneumatically operated alarms are fitted which require periodic testing, carbon dioxide is not to be used as an operating medium. Air operated alarms may be used provided that the air supply is clean and dry.

IR5.2.1.4.3 Where electrically operated alarms are used, the arrangements are to be such that the electric operating mechanism is located outside the pump room except where alarms are certified intrinsically safe.

5.2.2 Carbon dioxide systems

5.2.2.1 Quantity of fire extinguishing medium

5.2.2.1.1 For cargo spaces the quantity of carbon dioxide available, unless otherwise provided, is to be sufficient to give a minimum volume of free gas equal to 30% of the gross volume of the largest cargo space to be protected in the ship.

5.2.2.1.2 For vehicle spaces and ro-ro spaces which are not special category spaces, the quantity of carbon dioxide available are to be at least sufficient to give a minimum volume of free gas equal to 45% of the gross volume of the largest such cargo space which is capable of being sealed, and the arrangements are to be such as to ensure that at least two thirds of the gas required for the relevant space is introduced within 10 min. Carbon dioxide systems are not to be used for the protection of special category spaces.

5.2.2.1.3 For machinery spaces the quantity of carbon dioxide carried is to be sufficient to give a minimum volume of free gas equal to the larger of the following volumes, either:

.1 40% of the gross volume of the largest machinery space so protected, the volume to exclude that part of the casing above the level at which the horizontal area of the casing is 40% or less of the horizontal area of the space concerned taken midway between the tank top and the lowest part of the casing; or

.2 35% of the gross volume of the largest machinery space protected, including the casing.

5.2.2.1.4 The percentages in 5.2.2.1.3 above may be reduced to 35% and 30%, respectively, for cargo ships of less than 2,000 gross tonnage where two or more machinery spaces, which are not entirely separate, are considered as forming one space.

5.2.2.1.5 The volume of free carbon dioxide is to be calculated at 0.56 [m^3/kg].

5.2.2.1.6 For machinery spaces the fixed piping system is to be such that 85 per cent of the gas can be discharged into the space within 2 minutes. Calculation to prove the discharge time may be submitted for consideration of IRS.

5.2.2.1.7 For container and general cargo spaces (primarily intended to carry a variety of cargoes separately secured or packed) the fixed piping system is to be such that at least two thirds of the gas can be discharged into the space within 10 min. For solid bulk cargo spaces the fixed piping system is to be such that at least two thirds of the gas can be discharged into the space within 20 min. The system controls are to be arranged to allow one third, two thirds or the entire quantity of gas to be discharged based on the loading condition of the hold.

5.2.2.2 Controls

Carbon dioxide systems for the protection of ro-ro spaces, container holds equipped with integral reefer containers, spaces accessible by doors or hatches, and other spaces in which personnel normally work or to which they have access are to comply with the following requirements:

.1 Two separate controls are to be provided for releasing carbon dioxide into a protected space and to ensure the activation of the alarm. One control is to be used for opening the valve of the piping which conveys the gas into the protected space and a second control is to be used to discharge the gas from its storage containers.

Positive means are to be provided so they can only be operated in that order; and
Note : The requirement of positive means stated above is applicable to ships contracted for construction on or after 1 July 2010.

IR.1 The pre-discharge alarm may be activated before the two separate system release controls are operated (e.g. by a micro-switch that activates the pre-discharge alarm upon opening the release cabinet door as per 5.2.1.3.2). Therefore, the two separate controls for releasing carbon dioxide into the protected space (i.e. one control to open the valve of the piping which conveys the gas into the protected space and a second control used to discharge the gas from its storage containers) as per 5.2.2.2.1 can be independent of the control for activating the alarm (provided the minimum length of time required for operation of the alarm before the release of the medium is as per 5.2.1.3.2).

A single control for activation of the alarm is sufficient.

The “positive means” referred to in 5.2.2.2.1 for the correct sequential operation of the controls, is to be achieved by a mechanical and/or electrical interlock that does not depend on any operational procedure to achieve the correct sequence of operation.

.2 The two controls are to be located inside a release box clearly identified for the particular space. If the box containing the controls is to be locked, a key to the box is to be in a break-glass-type enclosure conspicuously located adjacent to the box.

IR.2 The above requirements for controls apply to the spaces requiring audible warning identified in 5.2.1.3.2 and IR5.2.1.3.2 b).

5.2.2.3 Testing of the installation

When the system has been installed, pressure-tested and inspected, the following is to be carried out:

.1 a test of the free air flow in all pipes and nozzles; and

.2 a functional test of the alarm equipment.

5.2.3 Requirements of steam systems

5.2.3.1 Steam is not generally accepted as a fire extinguishing medium in fixed-fire extinguishing systems. However restricted use of steam is permitted as an addition to the required fire extinguishing medium.

5.2.3.2 The boiler or boilers available for supplying steam are to have an evaporation of at least 1 [kg] of steam per hour for each 0.75 [m^3] of the gross volume of the largest space so protected. In addition to complying with the foregoing requirements, the systems in all respects are to be to the satisfaction of IRS. (Refer Part 4 of the Rules).

5.2.3.3 Steam is not to be used in spaces containing explosives.

5.2.3.4 Steam used for fire extinguishing purposes is not to be obtained from a supply of superheated steam.

5.2.4 Equivalent fixed gas fire-extinguishing systems for machinery spaces and cargo pump rooms

Fixed gas fire-extinguishing systems equivalent to those specified in 5.2.2 and 5.2.3 will be approved by IRS based on the requirements of the National Statutory Authority. (Refer to the Revised guidelines for the approval of equivalent fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces and cargo pump rooms (MSC/Circ.848) *amended by MSC.1/Circ.1267* and the Guidelines for the approval of fixed aerosol fire-extinguishing systems equivalent to fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces (MSC.1/Circ.1270)).

IR5.2.4 Container storage arrangement for equivalent fixed gas fire extinguishing systems

Agent containers having / filled with fire extinguishing medium, stored in a protected space are to be distributed throughout the space with bottles or groups of bottles located in at least six separate locations. Duplicate power release lines are to be arranged to release all bottles simultaneously. The release lines are to be so arranged that in the event of damage to any power release line, five sixth of the fire extinguishing gas can still be discharged. The bottle valves are considered to be part of the release lines and a single failure are to include also failure of the bottle valve.

For systems that need less than six cylinders (using the smallest bottles available), the total amount of extinguishing gas on the bottles are to be such that in the event of a single failure to one of the release lines (including bottle valve), five sixth of the fire extinguishing gas can still be discharged. This may be achieved by for instance using more extinguishing gas than required so that if one bottle is not discharging due to a single fault, the remaining bottles will discharge the minimum five sixth of the required amount of gas. This can be achieved with minimum two bottles. However, NOAEL values calculated at the highest expected engine room temperature are not to be exceeded when discharging the total amount of extinguishing gas simultaneously.

Systems that can not comply with the above, for instance systems using only one bottle located inside the protected space, can not be accepted. Such systems are to be designed with the bottle(s) located outside the protected space, in a dedicated room in compliance with Ch.3, 4.4.3.

IR5.2.5 Low-pressure carbon dioxide smothering systems

5.2.5.1 General

a) The rated amount of carbon dioxide, time of discharge into the protected space, location of nozzles in the protected spaces and signals warning that the smothering system is activated is to comply with the requirements of 5.2.2 relating to CO_2 high-pressure systems.

b) Vessel(s), refrigerating plants, control devices and other equipment of the smothering system are to be located in a space complying with rules applying to CO_2

high-pressure systems. The system control devices and the refrigerating plants are to be located within the same room where the pressure vessels are stored.

5.2.5.2 Vessel(s) and relevant devices

a) The rated amount of liquid carbon dioxide is to be stored in vessel(s) under the working pressure in the range of 18 to 22 bar. The normal liquid charge in the container is to be limited to provide sufficient vapour space to allow for expansion of the liquid under the maximum storage temperatures than can be obtained corresponding to the setting of the pressure relief valves but is not to exceed 95% of the volumetric capacity of the container.

b) The vessel(s) is to be designed, constructed and tested in accordance with the requirements of Pt.4, Ch.5 for pressure vessels. For this purpose the design pressure is to be taken not less than the relief valve setting. Besides, provision is to be made for:

- pressure gauge
- high pressure alarm: not more than setting of the relief valve
- low pressure alarm: not less than 18 bar
- branch pipes with stop valves for filling the vessel
- discharge pipes
- liquid CO_2 level indicator, fitted on the vessel(s)
- two safety relief valves arranged so that either valve can be shut off while the other is connected to the vessel. The setting of the relief valves is to be not less than 1.1 times working pressure. The capacity of each valve is to be such that the vapours generated under fire condition can be discharged with a pressure rise not more than 20% above the setting pressure. The discharge from the safety valves is to be led to the open.

c) The vessel(s) and outgoing pipes permanently filled with carbon dioxide are to have thermal insulation preventing the operation of the safety valve in 24 hours after de-energizing the plant, at ambient temperature of 45°C and an initial pressure equal to the starting pressure of the refrigeration unit. The insulating materials and their liners are to be to the satisfaction of IRS, having in mind, in particular, their fire resistance and mechanical properties, as well as protection against penetration of water vapours.

5.2.5.3 Refrigerating plant

a) The vessel(s) is to be serviced by two automated completely independent refrigerating units solely intended for this purpose, each comprising a compressor and the relevant prime mover, evaporator and condenser.

b) The refrigerating plant is to comply with the relevant requirements of Pt.5, Ch.23 in so far as they are applicable. The refrigerating capacity and the automatic control of each unit are to be so as to maintain the required temperature under conditions of continuous operation during 24 hours at the sea temperature upto 32°C and ambient air temperature upto 45°C.

c) In the event of failure of either one of the refrigerating units the other is to be actuated automatically. Provision is to be made for local manual control of the refrigerating plant.

d) Each electric refrigerating unit is to be supplied from the main switchboard busbars by a separate feeder.

Cooling water supply to the refrigerating plant (where required) is to be provided from at least two circulating pumps one of which being used as a stand-by. The stand-by pump may be a pump used for other services so long as its use for cooling would not interfere with any other essential service of the ship.

Cooling water is to be taken from not less than two sea connections, preferably one port and one starboard.

5.2.5.4 Pipes and fittings

a) The pipes, valves and fittings are to be in accordance with the requirements of IRS for a design pressure not less than the design pressure of the CO_2 vessels.

b) Safety relief devices are to be provided in each section of pipe that may be isolated by block valves and in which there could be a build-up of pressure in excess of the design pressure of any of the components.

c) The piping system is to be designed in such a way that the CO_2 flows through in liquid phase upto the discharge nozzles. To this end the pressure at the nozzles are to be not less than 10 bar.

5.2.5.5 Control of smothering system operation

The machinery alarm system is to be equipped with audible and visual alarms activated when:

- the pressure in the vessel(s) reaches the low and high values according to 5.2.5.2 a)
- any one of the refrigerating units fails to operate
- the lowest permissible level of the liquid in the vessels is reached.

5.2.5.6 Release control

a) The release of CO_2 is to be initiated manually.

b) If a device is provided which automatically regulates the discharge of the rated quantity of carbon dioxide into the protected spaces it is to be also possible to regulate the discharge manually.

If the system serves more than one space, means for control of discharge quantities of CO_2 is to be provided, e.g. automatic timer or accurate level indicators located at the control position(s).

5.2.5.7 Testing

a) The pipes, valves and fittings and assembled system are to be tested to satisfaction of the Surveyors.

b) The pipes from the vessel(s) to the release valves on the distribution manifold are to be subject to a pressure test to not less than 1.5 times the set pressure of the safety relief valves.

c) The pipes from the release valves on the distribution manifold to the nozzles are to be tested for tightness and free flow of CO_2, after assembly on board.

d) The refrigerating plant, after having been fitted on board is to be checked for its proper operation.

At the judgement of IRS, a discharge test may be required to check the fulfillment of the requirements of 5.2.5.4 c).

Section 6

Fixed Foam Fire-Extinguishing Systems

6.1 Application

This section details the specifications for fixed foam fire-extinguishing systems for the protection of machinery spaces in accordance with 4.4.1.1.2 of Chapter 3 , cargo spaces in accordance with 4.7.1.1 of Chapter 3, cargo pump-rooms in accordance with 4.9.1.2 of Chapter 3 and vehicle, special category and ro-ro spaces in accordance with 3.6.1.3 of Chapter 7. This section does not apply to cargo pump-rooms of chemical tankers carrying liquid cargoes referred to in 1.5.2 of Chapter 1, unless the Administration specifically accepts the use of these systems based on additional tests with alcohol-based fuel and alcohol resistant foam. Unless expressly provided otherwise, the requirements of this section are to apply to ships constructed on or after 1 January 2014.

6.2 Definitions

6.2.1 *Design filling rate* is at least the minimum nominal filling rate used during the approval tests.

6.2.2 *Foam is the extinguishing medium* produced when foam solution passes through a foam generator and is mixed with air.

6.2.*3 Foam solution* is a solution of foam concentrate and water.

6.2.*4 Foam concentrate* is a liquid which, when mixed with water in the appropriate concentration forms a foam solution.

6.2.5 *Foam delivery ducts* are supply ducts for introducing high-expansion foam into the protected space from foam generators located outside the protected space.

6.2.6 *Foam mixing ratio* is the percentage of foam concentrate mixed with water forming the foam solution.

6.2.*7 Foam generators* are discharge devices or assemblies through which high-expansion foam solution is aerated to form foam that is discharged into the protected space. Foam generators using inside air typically consist of a nozzle or set of nozzles and a casing. The casing is typically made of perforated steel/stainless steel plates shaped into a box that enclose the nozzle(s). Foam generators using outside air typically consist of nozzles enclosed within a casing that spray onto a screen. An electric, hydraulic or pneumatically driven fan is provided to aerate the solution.

6.2.8 *High-expansion foam fire-extinguishing systems* are fixed total flooding extinguishing systems that use either inside air or outside air for aeration of the foam solution. A high-expansion foam system consists of both the foam generators and the dedicated foam concentrate approved during the fire testing specified in 6.3.1.2

6.2.9 *Inside air foam system* is a fixed high-expansion foam fire-extinguishing system with foam generators located inside the protected space and drawing air from that space.

6.2.10 *Nominal flow rate* is the foam solution flow rate expressed in l/min

6.2.11 *Nominal application rate* is the nominal flow rate per area expressed in l/min/m^2

6.2.12 *Nominal foam expansion ratio* is the ratio of the volume of foam to the volume of foam solution from which it was made, under non-fire conditions, and at an ambient temperature of e.g. around 20ºC.

6.2.13 *Nominal foam production* is the volume of foam produced per time unit, i.e. nominal flow rate times nominal foam expansion ratio, expressed in m^3/min.

6.2.14 *Nominal filling rate* is the ratio of nominal foam production to the area, i.e. expressed in m^2/min.

6.2.15 *Nominal filling time* is the ratio of the height of the protected space to the nominal filling rate, i.e. expressed in minutes.

6.2.16 *Outside air foam system* is a fixed high-expansion foam system with foam generators installed outside the protected space that are directly supplied with fresh air.

6.3 Fixed high-expansion foam fire-extinguishing systems

6.3.1 Principal Performance

6.3.1.1 The system is to be be capable of manual release, and be designed to produce foam at the required application rate within 1 minute of release. Automatic release of the system is not permitted unless appropriate operational measures or interlocks are provided to prevent any local application systems required by 4.5.6 of chapter 3 from interfering with the effectiveness of the system.

6.3.1.2 The foam concentrates are to be approved based on the guidelines developed by IMO (MSC.1/Circ. 670). Different foam concentrate types are not to be mixed in a high-expansion foam system.

6.3.1.3 The system is to be capable of fire extinction and manufactured and tested to the satisfaction of IRS based on the guidelines developed by IMO (MSC.1/Circ.1384).

6.3.1.4 The system and its components are to be suitably designed to withstand ambient temperature changes, vibration, humidity, shock, clogging and corrosion normally encountered on ships. Piping, fittings and related components inside the protected spaces (except gaskets) are to be designed to withstand 925°C

6.3.1.5 System piping, foam concentrate storage tanks, components and pipe fittings in contact with the foam concentrate are to be compatible with the foam concentrate and be constructed of corrosion resistant materials such as stainless steel or equivalent. Other system piping and foam generators are to be full galvanized steel or equivalent. Distribution pipework has to have self-draining capability.

6.3.1.6 Means for testing the operation of the system and assuring the required pressure and flow are to be provided by pressure gauges at both inlets (water and foam concentrate supply) and at the outlet of the foam proportioner. A test valve is to be installed on the distribution piping downstream of the foam proportioner, along with orifices which reflect the calculated pressure drop of the system. All sections of piping are to be provided with connections for flushing, draining and purging with air. All nozzles are to be able to be removed for inspection in order to prove clear of debris.

6.3.1.7 Means are to be provided for the crew to safely check the quantity of foam concentrate and take periodic control samples for foam quality.

6.3.1.8 Operating instructions for the system are to be displayed at each operating position.

6.3.1.9 Spare parts are to be provided based on the manufacturer's instruction.

6.3.1.10 If an internal combustion engine is used as a prime mover for the seawater pump for the system, the fuel oil tank to the prime mover is to contain sufficient fuel to enable the pump to run on full load for at least 3 h and sufficient reserves of fuel are to be available outside the machinery space of category A to enable the pump to be run on full load for an additional 15 h. If the fuel tank serves other internal combustion engines simultaneously, the total fuel tank capacity is to be adequate for all connected engines.

6.3.1.11 The arrangement of foam generators and piping in the protected space is not to interfere with access to the installed machinery for routine maintenance activities.

6.3.1.12 The system source of power supply, foam concentrate supply and means of controlling the system are to be readily accessible and simple to operate, and are to be arranged at positions outside the protected space not likely to be cut off by a fire in the protected space. All electrical components directly connected to the foam generators are to have at least an IP 54 rating.

6.3.1.13 The piping system is to be sized in accordance with a hydraulic calculation technique to ensure availability of flows and pressures required for correct performance of the system.

6.3.1.14 The arrangement of the protected spaces is to be such that they may be ventilated as the space is being filled with foam. Procedures are to be provided to ensure that upper level dampers, doors and other suitable openings are kept open in case of a fire. For inside air foam systems, spaces below 500 m^3 need not comply with this requirement.

6.3.1.15 Onboard procedures are to be established to require personnel re-entering the protected space after a system discharge to wear breathing apparatus to protect them from oxygen deficient air and products of combustion entrained in the foam blanket.

6.3.1.16 Installation plans and operating manuals are to be supplied to the ship and be readily available on board. A list or plan is to be displayed showing spaces covered and the location of the zone in respect of each section. Instructions for testing and maintenance are to be available on board.

6.3.1.17 All installation, operation and maintenance instructions/plans for the system are to be in the working language of the ship. If the working language of the ship is not English, French, nor Spanish, a translation into one of these languages is to be included.

6.3.1.18 The foam generator room is to be ventilated to protect against overpressure, and are to be heated to avoid the possibility of freezing.

6.3.1.19 The quantity of foam concentrate available is to be sufficient to produce a volume of foam equal to at least five times the volume of the largest protected space enclosed by steel bulkheads, at the nominal expansion ratio, or enough for 30 min of full operation for the largest protected space, whichever is greater.

6.3.1.20 Machinery spaces, cargo pump-rooms, vehicle spaces, ro-ro spaces and special category spaces are to be provided with audible and visual alarms within the protected space warning of the release of the system. The alarms are to operate for the length of time needed to evacuate the space, but in no case less than 20 s.

6.3.2 Inside air foam systems:

6.3.2.1 *Systems for the protection of machinery spaces and cargo pump rooms*

6.3.2.1.1 The system is to be supplied by both main and emergency sources of power. The emergency power supply is to be provided from outside the protected space.

6.3.2.1.2 Sufficient foam-generating capacity is to be provided to ensure the minimum design filling rate for the system is met and in addition is to be adequate to completely fill the largest protected space within 10 min.

IR 6.3.2.1.2 The term “largest protected space” applies to a machinery space of category A protected by a fixed high-expansion foam fire-extinguishing system complying with this section. Where such a machinery space includes a casing (e.g. an engine casing in a machinery space of category A containing internal combustion machinery, and/or a boiler), the volume of such casing, above the level up to which foam is to be filled to protect the highest position of the fire risk objects within the machinery space, need not be included in the volume of the protected space (Fig 6.3.2.1.2(a)). The level up to which foam is to be filled to protect the highest positioned fire risk objects within the machinery space is not to be less than:

> 1 m above the highest point of any such object; or
> The lowest part of the casing, whichever is higher (Fig 6.3.2.1.2 (a)).

Where such a machinery space does not include a casing, the volume of the largest protected space is to be that of the space in its entirety, irrespective of the location of any fire risk object therein (Fig 6.3.2.1.2 (b)).

Fire risk objects include, but may not be limited to, those listed in 3.31 and 3.34 of chapter 1. Although not referred to in those Clauses, they may also include items having a similar fire risk such as exhaust gas boilers or oil fuel tanks

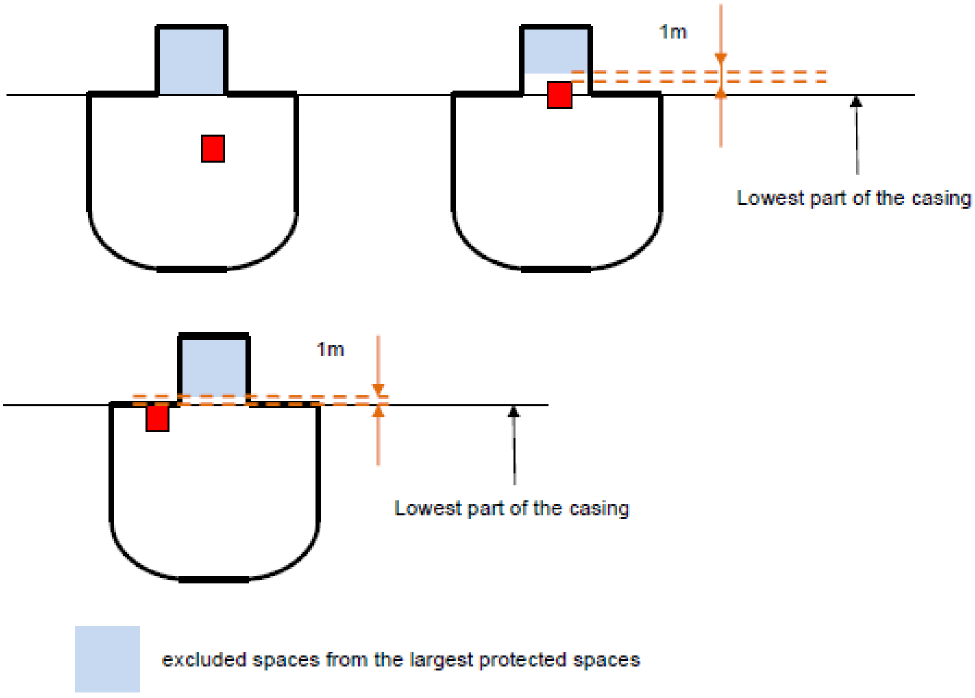


Fig 6.3.2.1.2 (a) Machinery Space including Casing

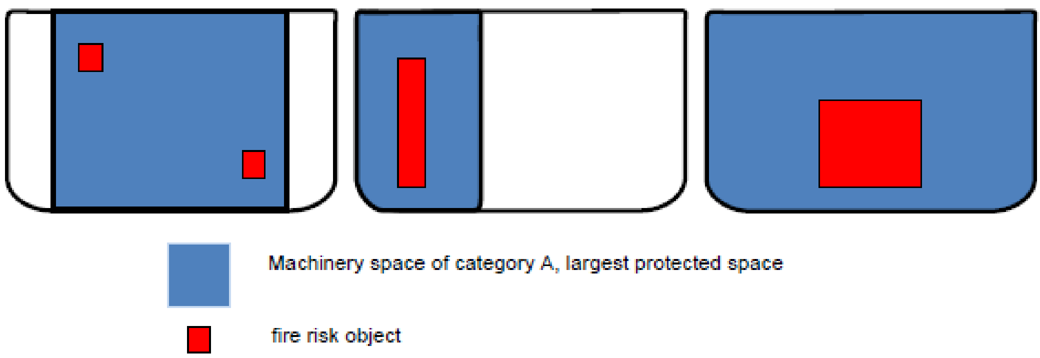


Fig 6.3.2.1.2 (b) Machinery Space not including a Casing

6.3.2.1.3 The arrangement of foam generators is in general to be designed based on the approval test results. A minimum of two generators are to be installed in every space containing combustion engines, boilers, purifiers, and similar equipment. Small workshops and similar spaces may be covered with only one foam generator.

6.3.2.1.4 Foam generators are to be uniformly distributed under the uppermost ceiling in the protected spaces including the engine casing. The number and location of foam generators are to be adequate to ensure all high risk areas are protected in all parts and at all levels of the spaces. Extra foam generators may be required in obstructed locations. The foam generators are to be arranged with at least 1 m free space in front of the foam outlets, unless tested with less clearance. The generators are to be located behind main structures, and above and away from engines and boilers in positions where damage from an explosion is unlikely.

6.3.2.2 *Systems for the protection of vehicle, ro-ro, special category and cargo spaces.*

6.3.2.2.1 The system is to be supplied by the ship's main power source. An emergency power supply is not required.

6.3.2.2.2 Sufficient foam-generating capacity is to be provided to ensure the minimum design filling rate for the system is met and in addition is to be adequate to completely fill the largest protected space within 10 min. However, for systems protecting vehicle and ro-ro spaces and special category spaces, with decks that are reasonably gas-tight and that have a deck height of 3 m or less, the filling rate are to be not less than two thirds of the design filling rate and in addition sufficient to fill the largest protected space within 10 min.

6.3.2.2.3 The system may be divided into sections, however, the capacity and design of the system is to be based on the protected space demanding the greatest volume of foam. Adjacent protected spaces need not be served simultaneously if the boundaries between the spaces are "A" class divisions.

6.3.2.2.4 The arrangement of foam generators are in general to be designed based on the approval test results. The number of generators may be different, but the minimum design filling rate determined during approval testing is to be provided by the system. A minimum of two generators are to be installed in every space. The foam generators are to be arranged to uniformly distribute foam in the protected spaces, and the layout is to take into consideration obstructions that can be expected when cargo is loaded on board. As a minimum, generators are to be located on every second deck, including movable decks. The horizontal spacing of the generators is to ensure rapid supply of foam to all parts of the protected space. This is to be established on the basis of full scale tests.

6.3.2.2.5 The foam generators are to be arranged with at least 1 m free space in front of the foam outlets, unless tested with less clearance.

6.3.3 Outside air foam systems

6.3.3.1 Systems for the protection of machinery spaces and cargo pump-rooms:

6.3.3.1.1 The system is to be supplied by both main and emergency sources of power. The emergency power supply is to be provided from outside the protected machinery space.

6.3.3.1.2 Sufficient foam-generating capacity is to be provided to ensure the minimum design filling rate for the system is met and in addition is to be adequate to completely fill the largest protected space within 10 min.

6.3.3.1.3 The arrangement of foam delivery ducts are in general to be designed based on the approval test results. The number of ducts may be different, but the minimum design filling rate determined during approval testing is to be provided by the system. A minimum of two ducts are to be installed in every space containing combustion engines, boilers, purifiers, and similar equipment. Small workshops and similar spaces may be covered with only one duct.

6.3.3.1.4 Foam delivery ducts are to be uniformly distributed under the uppermost ceiling in the protected spaces including the engine casing. The number and location of ducts are to be adequate to ensure all high risk areas are protected in all parts and at all levels of the spaces. Extra ducts may be required in obstructed locations. The ducts are to be arranged with at least 1 m free space in front of the foam delivery ducts, unless tested with less clearance. The ducts are to be located behind main structures, and above and away from engines and boilers in positions where damage from an explosion is unlikely.

6.3.3.1.5 The arrangement of the foam delivery ducts are to be such that a fire in the protected space will not affect the foam-generating equipment. If the foam generators are located adjacent to the protected space, foam delivery ducts are to be installed to allow at least 450 mm of separation between the generators and the protected space, and the separating divisions are to be class "A-60" rated. Foam delivery ducts are to be constructed of steel having a thickness of not less than 5 mm. In addition, stainless steel dampers (single or multi-bladed) with a thickness of not less than 3 mm are to be installed at the openings in the boundary bulkheads or decks between the foam generators and the protected space. The dampers are to be automatically operated (electrically, pneumatically or hydraulically) by means of remote control of the foam generator related to them, and arranged to remain closed until the foam generators begin operating.

6.3.3.1.6The foam generators are to be located where an adequate fresh air supply can be arranged.

6.3.3.2 Systems for the protection of vehicle and ro-ro spaces and special category and cargo spaces:

6.3.3.2.1 The system is to be supplied by the ship's main power source. An emergency power supply is not required.

6.3.3.2.2 Sufficient foam-generating capacity is to be provided to ensure the minimum design filling rate for the system is met and in addition is to be adequate to completely fill the largest protected space within 10 min. However, for systems protecting vehicle and ro-ro spaces and special category spaces, with decks that are reasonably gas-tight and that have a deck height of 3 m or less, the filling rate is not to be less than two thirds of the design filling rate and in addition sufficient to fill the largest protected space within 10 min.

6.3.3.2.3 The system may be divided into sections; however, the capacity and design of the system is to be based on the protected space demanding the greatest volume of foam. Adjacent protected spaces need not be served simultaneously if the boundaries between the spaces are "A" class divisions.

6.3.3.2.4 The arrangement of foam delivery ducts are in general to be designed based on the approval test results. The number of ducts may be different, but the minimum design filling rate determined during approval testing is to be provided by the system. A minimum of two ducts are to be installed in every space. The foam generators are to be arranged to uniformly distribute foam in the protected spaces, and the layout are to take into consideration obstructions that can be expected when cargo is loaded on board. As a minimum, ducts are to be led to every second deck, including movable decks. The horizontal spacing of the ducts is to ensure rapid supply of foam to all parts of the protected space. This is to be established on the basis of full scale tests.

6.3.3.2.5 The system is to be arranged with at least 1 m free space in front of the foam outlets, unless tested with less clearance.

6.3.3.2.6 The arrangement of the foam delivery ducts are to be such that a fire in the protected space will not affect the foam-generating equipment. If the foam generators are located adjacent to the protected space, foam delivery ducts are to be installed to allow at least 450 mm of separation between the generators and the protected space, and the separating divisions are to be class "A-60" rated. Foam delivery ducts are to be constructed of steel having a thickness of not less than 5 mm. In addition, stainless steel dampers (single or multi-bladed) with a thickness of not less than 3 mm are to be installed at the openings in the boundary bulkheads or decks between the foam generators and the protected space. The dampers are to be automatically operated (electrically, pneumatically or hydraulically) by means of remote control of the foam generator related to them, and arranged to remain closed until the foam generators begin operating.

6.3.3.2.7 The foam generators are to be located where an adequate fresh air supply can be arranged.

6.3.4 Testing requirements

6.3.4.1 After installation, the pipes, valves, fittings and assembled systems are to be tested to the satisfaction of the Administration, including functional testing of the power and control systems, water pumps, foam pumps, valves, remote and local release stations and alarms. Flow at the required pressure is to be verified for the system using orifices fitted to the test line. In addition, all distribution piping is to be flushed with freshwater and blown through with air to ensure that the piping is free of obstructions.

6.3.4.2 Functional tests of all foam proportioners or other foam mixing devices are to be carried out to confirm that the mixing ratio tolerance is within +30 to 0% of the nominal mixing ratio defined by the system approval. For foam proportioners using foam concentrates of Newtonian type with kinematic viscosity equal to or less than 100 cSt at 0ºC and density equal to or less than 1,100 kg/m^3, this test can be performed with water instead of foam concentrate. Other arrangements are to be tested with the actual foam concentrate.

6.3.5 Systems using outside air with generators installed inside the protected space:
Systems using outside air but with generators located inside the protected space and supplied by fresh air ducts may be accepted provided that these systems have been shown to have performance and reliability equivalent to systems defined in 6.3.3. For acceptance the following minimum design features will be considered:

.1 lower and upper acceptable air pressure and flow rate in supply ducts;

.2 function and reliability of damper arrangements;

.3 arrangements and distribution of air delivery ducts including foam outlets; and

.4 separation of air delivery ducts from the protected space.

6.4 Fixed low-expansion foam fire-extinguishing systems

6.4.1 Quantity and foam concentrates

6.4.1.1 The foam concentrates of low-expansion foam fire-extinguishing systems are to be approved based on the guidelines adopted by IMO. (Refer to the Guidelines for performance and testing criteria and surveys of low expansion foam concentrates for fixed fire-extinguishing systems (MSC/Circ.1312).

6.4.1.2 The system is to be capable of discharging through fixed discharge outlets in not more than 5 min a quantity of foam sufficient to produce an effective foam blanket over the largest single area over which oil fuel is liable to spread.

6.4.2 Installation requirements

6.4.2.1 Means are to be provided for the effective distribution of the foam through a permanent system of piping and control valves or cocks to suitable discharge outlets, and for the foam to be effectively directed by fixed sprayers on other main fire hazards in the protected space. The means for effective distribution of the foam are to be proven acceptable to IRS through calculation or by testing.

6.4.2.2 The means of control of any such systems is to be readily accessible and simple to operate and are to be grouped together in as few locations as possible at positions not likely to be cut off by a fire in the protected space.

IR6.4.2.3 The distribution pipes are to be of steel and galvanized, at least, internally.

Section 7

Fixed Pressure Water-Spraying and Water-Mist Fire-Extinguishing Systems

7.1 Application

This section details the specifications for fixed pressure water-spraying and water-mist fire-extinguishing systems as required by Ch.3, Sec.4

7.2 Engineering specifications

7.2.1 Fixed pressure water-spraying fire-extinguishing systems

Fixed pressure water spraying fire extinguishing systems for machinery spaces and cargo pump rooms are to be approved by IRS based on guidelines developed by IMO (Revised Guidelines for the approval of equivalent water based fire extinguishing systems for machinery spaces and cargo pump rooms (MSC/Circ. 1165 as amended by MSC.1/Circ.1237 and MSC.1/Circ.1269).

7.2.2 Equivalent water-mist fire-extinguishing systems

Water-mist fire-extinguishing systems for machinery spaces and cargo pump-rooms are to be approved based on the guidelines developed by IMO (Refer 7.2.1).

7.2.3 Fixed pressure water spraying fire extinguishing system for cabin balconies

Fixed pressure water spraying fire extinguishing system for cabin balconies is to be approved based on the guidelines developed by IMO (MSC.1 Circ.1268).

7.2.4 Fixed water-based fire-fighting systems for ro-ro spaces, vehicle spaces and special category spaces

Fixed water-based fire-fighting systems for ro-ro spaces, vehicle spaces and special category spaces are to be approved by the IRS based on guidelines for approval of fixed water-based fire-fighting systems for ro-ro spaces and special category spaces (MSC.1/Circ.1430).

Section 8

Automatic Sprinkler, Fire Detection and Fire Alarm Systems

8.1 Application

This section details the specifications for automatic sprinkler, fire detection and fire alarm systems as required by Ch.3, Sec.4.

8.2 Engineering specifications

8.2.1 General

8.2.1.1 Type of sprinkler systems

The automatic sprinkler systems are to be of the wet pipe type, but small exposed sections may be of the dry pipe type where this is considered a necessary precaution, e.g. within refrigerated chambers. Control stations, where water may cause damage to essential equipment, maybe fitted with a dry pipe system as permitted by 4.6.1.1 of Chapter 3. Saunas are to be fitted with a dry pipe system, with sprinkler heads having an operating temperature up to 140°C.

8.2.1.2 Sprinkler systems equivalent to those specified in paragraphs 8.2.2 to 8.2.4

Automatic sprinkler systems equivalent to those specified in 8.2.2 to 8.2.4 are to be approved based on the requirements of the National Statutory Authority. (Refer to the Revised Guidelines for approval of sprinkler systems equivalent to that referred to in SOLAS regulation II-2/12 as adopted by IMO by resolution A.800(19)).

8.2.2 Sources of power supply

8.2.2.1 Passenger ships

There is to be not less than two sources of power supply for the sea water pump and automatic alarm and detection system. Where the sources of power for the pump are electrical, these are to be a main generator and an emergency source of power. One supply for the pump is to be taken from the main switchboard, and one from the emergency switchboard by separate feeders reserved solely for that purpose. The feeders are to be so arranged as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk except in so far as it is necessary to reach the appropriate switchboards, and are to be run to an automatic changeover switch situated near the sprinkler pump. This switch is to permit the supply of power from the main switchboard so long as a supply is available therefrom, and be so designed that upon failure of that supply it will automatically change over to the supply from the emergency switchboard. The switches on the main switchboard and the emergency switchboard are to be clearly labelled and normally kept closed. No other switch is to be permitted in the feeders concerned. One of the sources of power supply for the alarm and detection system is to be an emergency source. Where one of the sources of power for the pump is an internal combustion engine it is to, in addition to complying with the provisions of 8.2.4.3, be so situated that a fire in any protected space will not affect the air supply to the machinery.

8.2.2.2 Cargo ships

There are not to be less than two sources of power supply for the sea water pump and automatic alarm and detection system. If the pump is electrically driven it is to be connected to the main source of electrical power, which is to be capable of being supplied by at least two generators. The feeders are to be so arranged as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk except in so far as it is necessary to reach the appropriate switchboards. One of the sources of power supply for the alarm and detection system is to be an emergency source. Where one of the sources of power for the pump is an internal combustion engine it is in addition to complying with the provisions of 8.2.4.3, be so situated that a fire in any protected space will not affect the air supply to the machinery.

8.2.3 Component requirements

8.2.3.1 Sprinklers

8.2.3.1.1 The sprinklers are to be resistant to corrosion by marine atmosphere. In accommodation and service spaces the sprinklers are to come into operation within the temperature range from 68° to 79°C, except that in locations such as drying rooms, where high ambient temperatures might be expected, the operation temperature may be increased by not more than 30°C above the maximum deckhead temperature.

8.2.3.1.2 A quantity of spare sprinkler heads are to be provided for all types and ratings installed on the ship as follows:

Total number of heads	Required number of spares
<300	6
300 to 1000	12
>1000	24

The number of spare sprinkler heads of any type need not exceed the total number of heads installed of that type.

8.2.3.2 Pressure tanks

8.2.3.2.1 A pressure tank having a volume equal to at least twice that of the charge of water specified herein is to be provided. The tank is to contain a standing charge of fresh water, equivalent to the amount of water which would be discharged in one minute by the pump referred to in 8.2.3.3.2, and the arrangements are to provide for maintaining an air pressure in the tank such as to ensure that where the standing charge of fresh water in the tank has been used the pressure will be not less than the working pressure of the sprinkler, plus the pressure exerted by a head of water measured from the bottom of the tank to the highest sprinkler in the system. Suitable means of replenishing the air under pressure and of replenishing the fresh water charge in the tank are to be provided. A glass gauge is to be provided to indicate the correct level of the water in the tank.

8.2.3.2.2 Means are to be provided to prevent the passage of sea water into the tank.

8.2.3.3 Sprinkler pumps

8.2.3.3.1 An independent power pump is to be provided solely for the purpose of continuing automatically the discharge of water from the sprinklers. The pump is to be brought into action automatically by the pressure drop in the system before the standing fresh water charge in the pressure tank is completely exhausted.

8.2.3.3.2 The pump and the piping system are to be capable of maintaining the necessary pressure at the level of the highest sprinkler to ensure a continuous output of water sufficient for the simultaneous coverage of a minimum area of 280 [m^2] at the application rate specified in 8.2.5.2.3. The hydraulic capability of the system is to be confirmed by the review of hydraulic calculations, followed by a test of the system, if deemed necessary by IRS.

8.2.3.3.3 The pump is to be fitted, on the delivery side, a test valve with a short open-ended discharge pipe. The effective area through the valve and pipe is to be adequate to permit the release of the required pump output while maintaining the pressure in the system specified in 8.2.3.2.1.

8.2.4 Installation requirements

8.2.4.1 General

Any parts of the system which may be subjected to freezing temperatures in service is to be suitably protected against freezing.

8.2.4.2 Piping arrangements

8.2.4.2.1 Sprinklers are to be grouped into separate sections, each of which is to contain not more than 200 sprinklers. In passenger ships any section of sprinklers is not to serve more than two decks and is not to be situated in more than one main vertical zone. However, a section of sprinklers to serve more than two decks or situated in more than one main vertical zone, may be permitted, if it is shown that the protection of the ship against fire will not thereby be reduced.

8.2.4.2.2 Each section of sprinklers is to be capable of being isolated by one stop valve only. The stop valve in each section is to be readily accessible in a location outside the associated section or in cabinets within stairway enclosures. The valve’s location is to be clearly and permanently indicated. Means are to be provided to prevent the operation of the stop valves by any unauthorized person.

8.2.4.2.3 A test valve is to provided for testing the automatic alarm for each section of sprinklers by a discharge of water equivalent to the operation of one sprinkler. The test valve for each section is to be situated near the stop valve for that section.

8.2.4.2.4 The sprinkler system is to have a connection from the ship's fire main by way of a lockable screw-down non-return valve at the connection which will prevent a backflow from the sprinkler system to the fire main.

8.2.4.2.5 A gauge indicating the pressure in the system is to be provided at each section stop valve and at a central station.

8.2.4.2.6 The sea inlet to the pump wherever possible is to be in the space containing the pump and is to be so arranged that when the ship is afloat it will not be necessary to shut off the supply of sea water to the pump for any purpose other than the inspection or repair of the pump.

8.2.4.3 Location of systems

The sprinkler pump and tank are to be situated in a position reasonably remote from any machinery space of category A and are not to be situated in any space required to be protected by the sprinkler system.

8.2.5 System control requirements

8.2.5.1 Ready availability

8.2.5.1.1 Any required automatic sprinkler, fire detection and fire alarm system is to be capable of immediate operation at all times and no action by the crew is to be necessary to set it in operation.

8.2.5.1.2 The automatic sprinkler system is to be kept charged at the necessary pressure and is to have provision for a continuous supply of water as required in this chapter.

8.2.5.2 Alarm and indication

8.2.5.2.1 Each section of sprinklers is to include means for giving a visual and audible alarm signal automatically at one or more indicating units whenever any sprinkler comes into operation. Such alarm systems are to be such as to indicate if any fault occurs in the system. Such units are to indicate in which section served by the system a fire has occurred and are to be centralised on the navigating bridge or in the continuously manned central control station and, in addition, visible and audible alarms from the unit are also to be placed in a position other than on the aforementioned spaces to ensure that the indication of fire is immediately received by the crew.

8.2.5.2.2 Switches are to be provided at one of the indicating positions referred to in 8.2.5.2.1 which will enable the alarm and the indicators for each section of sprinklers to be tested.

8.2.5.2.3 Sprinklers are to be placed in an overhead position and spaced in a suitable pattern to maintain an average application rate of not less than 5 [litres/m^2] per minute over the nominal area covered by the sprinklers. For this purpose, nominal area is to be taken as the gross horizontal projection of the area to be covered. The use of sprinklers providing other amounts of water suitably distributed, will be considered provided they are shown to be not less effective.

8.2.5.2.4 A list or plan is to be displayed at each indicating unit showing the spaces covered and the location of the zone in respect of each section. Suitable instructions for testing and maintenance are to be available.

8.2.5.3 Testing

Means are to be provided for testing the automatic operation of the pump on reduction of pressure in the system.

IR8.2.5.4 Stowage of spare sprinklers

8.2.5.4.1 Spare sprinklers are to be stowed in boxes or holders provided for that purpose, together with a tool suitable for removing and installing sprinkler heads. The boxes or holders are to be situated near the control valve for the section, and are to be clearly and permanently marked to indicate their contents.

Section 9

Fixed Fire Detection and Fire Alarm Systems

9.1 Application

This chapter details the specifications for fixed fire detection and fire alarm systems as required by Ch.3, Sec.1.

IR9.1 Definitions

Section is a group of fire detectors and manually operated call points as reported in the indicating unit(s).

Section identification capability means a system with the capability of identifying the section in which a detector or manually operated call point has activated.

Individually identifiable means a system with the capability to identify the exact location and type of detector or manually activated call point which has activated, and which can differentiate the signal of that device from all others.

9.2 Engineering specifications

9.2.1 General requirements

9.2.1.1 Any required fixed fire detection and fire alarm system with manually operated call points is to be capable of immediate operation at all times (this does not require a backup control panel). Notwithstanding this, particular spaces may be disconnected, for example, workshops during hot work and ro-ro spaces during on and off-loading. The means for disconnecting the detectors is to be designed to automatically restore the system to normal surveillance after a predetermined time that is appropriate for the operation requiring disconnection of the detectors. The space is to be manned or provided with a fire patrol when the required detectors are disconnected. Detectors in all other spaces are to remain operational.

9.2.1.2 The fire detection system is to be designed to:

.1 control and monitor input signals from all connected fire and smoke detectors and manual call points;

.2 provide output signals to the navigation bridge, continuously manned central control station or onboard safety centre to notify the crew of fire and fault conditions;

.3 monitor power supplies and circuits necessary for the operation of the system for loss of power and fault conditions; and

.4 the system may be arranged with output signals to other fire safety systems including:

- .1 paging systems, fire alarm or public address systems;
- .2 fan stops;
- .3 fire doors;
- .4 fire dampers;
- .5 sprinkler systems;
- .6 smoke extraction systems;
- .7 low-location lighting systems;
- .8 fixed local application fire-extinguishing systems;
- .9 closed circuit television (CCTV) systems; and
- .10 other fire safety systems.

IR9.2.1.2 However, for passenger ships, watertight doors complying with Reg.II-1/13 of SOLAS which also serve as fire doors are not to be closed automatically in case of detection of fire.

9.2.1.3 The fire detection system may be connected to a decision management system provided that:

.1 the decision management system is proven to be compatible with the fire detection system;

.2 the decision management system can be disconnected without losing any of the functions required by this section for the fire detection system; and

.3 any malfunction of the interfaced and connected equipment does not propagate to the fire detection system under any circumstance.

9.2.1.4 Detectors and manual call points are to be connected to dedicated sections of the fire detection system. Other fire safety functions, such as alarm signals from the sprinkler valves, may be permitted if in separate sections.

9.2.1.5 The system and equipment are to be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships. All electrical and electronic equipment on the bridge or in the vicinity of the bridge are to be tested for electromagnetic compatibility, based on the IMO resolution (A.813(19)).

9.2.1.6 Fixed fire detection and fire alarm systems with individually identifiable fire detectors are to be so arranged that:

.1 means are provided to ensure that any fault (e.g. power break, short circuit, earth, etc.) occurring in the section will not prevent the continued individual identification of the remainder of the connected detectors in the section;

.2 all arrangements are made to enable the initial configuration of the system to be restored in the event of failure (e.g. electrical, electronic, informatics, etc.);

.3 the first initiated fire alarm will not prevent any other detector from initiating further fire alarms; and

.4 no section will pass through a space twice. When this is not practical (e.g. for large public spaces), the part of the section which by necessity passes through the space for a second time is to be installed at the maximum possible distance from the other parts of the section.

9.2.1.7 In passenger ships, the fixed fire detection and fire alarm system is to be capable of remotely and individually identifying each detector and manually operated call point. Fire detectors fitted in passenger ship cabins, when activated, are also to be capable of emitting, or cause to be emitted, an audible alarm within the space where they are located. In cargo ships and on passenger ship cabin balconies the fixed fire detection and fire alarm system is to have section identification capability as a minimum.

9.2.1.8 Fixed fire detection and fire alarm systems for cabin balconies are to be approved by IRS, based on the guidelines developed by the IMO (MSC.1 Circ.1242).

9.2.2 Sources of power supply

9.2.2.1 There are to be not less than two sources of power supply for the electrical equipment used in the operation of the fixed fire detection and fire alarm system, one of which is to be an emergency source. The supply is to be provided by separate feeders reserved solely for that purpose. Such feeders are to run to an automatic change over switch situated in or adjacent to the control panel for the fire detection system. The change over switch shall be arranged such that a fault will not result in the loss of both power supplies. The main/ emergency feeder is to run from the respective switchboard to the change-over switch without passing through any other distributing switchboard.

9.2.2.2 The operation of the automatic changeover switch or a failure of one of the power supplies shall not result in loss of fire detection capability. Where a momentary loss of power would cause degradation of the system, a battery of adequate capacity shall be provided to ensure continuous operation during changeover.

9.2.2.3 There is to be sufficient power to permit the continued operation of the system with all detectors activated, but not more than 100 if the total exceeds this figure.

9.2.2.4 The emergency source of power specified in 9.2.2.1 may be supplied by accumulator batteries or from emergency switchboard. The power source is to be sufficient to maintain the operation of the fire detection and fire alarm system for the periods specified in Pt. 4, Ch. 8, Sec 2.8 and at the end of that period, is to be capable of operating all connected visual and audible fire alarm signals for a period of at least 30 min.

9.2.2.5 Where the system is supplied from accumulator batteries, they shall be located in or adjacent to the control panel for the fire detection system, or in another location suitable for use in an emergency. The rating of the battery charge unit shall be sufficient to maintain the normal output power supply to the fire detection system while recharging the batteries from a fully discharged condition.

9.2.3 Component requirements

9.2.3.1 Detectors

9.2.3.1.1 Detectors are to be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered by IRS provided that they are no less sensitive than such detectors.

9.2.3.1.2 Smoke detectors required in all stairways, corridors and escape routes within accommodation spaces are to be certified to operate before the smoke density exceeds 12.5% obscuration per metre, but not until the smoke density exceeds 2% obscuration per metre, when tested according to standards EN 54:2001 and IEC 60092-504. Alternative testing standards may be accepted by IRS. Smoke detectors to be installed in other spaces are to operate within sensitivity limits to the satisfaction of IRS having regard to the avoidance of detector insensitivity or over-sensitivity.

9.2.3.1.3 Heat detectors are to be certified to operate before the temperature exceeds 78°C but not until the temperature exceeds 54°C, when the temperature is raised to those limits at a rate less than 1°C per minute, when tested according to standards EN 54 and IEC 60092-504. Alternative testing standards may be accepted by IRS. At higher rates of temperature rise, the heat detector is to operate within temperature limits to the satisfaction of the Surveyors having regard to the avoidance of detector insensitivity or oversensitivity.

9.2.3.1.4 The operation temperature of heat detectors in drying rooms and similar spaces of a normal high ambient temperature may be up to 130°C, and up to 140°C in saunas.

9.2.3.1.5 Flame detectors are to be tested according to standards EN 54-10:2001 and IEC 60092-504.

9.2.3.1.6 All detectors are to be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.

9.2.3.1.7 Detectors fitted in hazardous areas are to be tested and approved for such service. Detectors required by Pt. 6, Ch. 7, Sec 3.4 and installed in spaces that comply with Pt. 6, Ch. 7, Sec 3.3.2.2 need not be suitable for hazardous areas. Detectors fitted in spaces carrying dangerous goods, required by Pt. 6, Ch. 7, Table 2.3 to comply with Pt. 6, Ch. 7, Cl. 2.3.2 are to be suitable for hazardous areas.

9.2.3.2 Control panel

The control panel for the fire detection system is to be tested according to standards EN 54-2:1997, EN 54-4:1997 and IEC 60092-504. Alternative standards may be accepted by IRS.

9.2.3.3 Cables

Cables used in the electrical circuits are to be flame retardant according to standard IEC 60332-1. On passenger ships, cables routed through other main vertical zones that they serve, and cables to control panels in an unattended fire control station are to be fire resisting according to standard IEC 60331, unless duplicated and well separated.

9.2.4 Installation requirements

9.2.4.1 Sections

9.2.4.1.1 Detectors and manually operated call points are to be grouped into sections.

9.2.4.1.2 A section of fire detectors which covers a control station, a service space or an accommodation space is not to include a machinery space of category A or a ro-ro space. A section of fire detectors which covers a ro-ro space is to not include a machinery space of category A. For fixed fire detection and fire alarm systems with remotely and individually identifiable fire detectors, a section covering fire detectors in accommodation, service spaces and control station is not to include fire detectors in machinery spaces of category A or ro-ro spaces.

9.2.4.1.3 Where the fixed fire detection and fire alarm system does not include means of remotely identifying each detector individually, no section covering more than one deck within accommodation spaces, service spaces and control stations, are normally to be provided except a section which covers an enclosed stairway. In order to avoid delay in identifying the source of fire, the number of enclosed spaces included in each section is to be limited as acceptable to IRS. If the detection system is fitted with remotely and individually identifiable fire detection, the sections may cover several decks and serve any number of enclosed spaces.

9.2.4.1.4 In passenger ships, a section of detectors and manually operated call points are not to be situated in more than one main vertical zone, except on cabin balconies.

9.2.4.2 Positioning of detectors

9.2.4.2.1 Detectors are to be located for optimum performance. Positions near beams and ventilation ducts or other positions where patterns of air flow could adversely affect performance and positions where impact or physical damage is likely is to be avoided. Detectors which are located on the overhead are to be a minimum distance of 0.5 [m] away from bulkheads, except in corridors, lockers and stairways.

9.2.4.2.2 The maximum spacing of detectors is to be in accordance with the Table 9.1.

IRS may require or permit different spacing to that specified in the above table if based upon test data which demonstrate the characteristics of the detectors. Detectors located below moveable ro-ro decks are to be in accordance with the above.

9.2.4.2.3 Detectors in stairways are to be located at least at the top level of the stair and at every second level beneath.

9.2.4.2.4 When fire detectors are installed in freezers, drying rooms, saunas, parts of galleys used to heat food, laundries and other spaces where steam and fumes are produced, heat detectors may be used.

9.2.4.2.5 Where a fixed fire detection and fire alarm system is required by Pt. 6, Ch. 3, Sec 1.5, spaces having little or no fire risk need not be fitted with detectors. Such spaces include void spaces with no storage of combustibles, private bathrooms, public toilets, fire-extinguishing medium storage rooms, cleaning gear lockers (in which flammable liquids are not stowed), open deck spaces and enclosed promenades having little or no fire risk and that are naturally ventilated by permanent openings.

IR9.2.4.2.5 Guidance Note : The following categories of spaces having little or no fire risk generally need not be fitted with detectors:

a) For ships carrying more than 36 passengers (See Ch.3, 3.2.2.3.2):

Category (5) Open deck spaces
Category (9) Sanitary and similar spaces
Category (10) Tanks and voids having little or no fire risk.

b) For ships carrying less than 36 passengers (See Ch.3, 3.2.2.4.2):

Category (5) Service spaces (low risk)
Category (10) Open decks

c) For cargo ships except tankers, (when method IIC or IIIC is adopted) (See Ch.3, 3.2.3.3.2):

Category (5) Service spaces (low risk)
Category (10) Open decks.

Table 9.1 : Spacing of detectors

Type of detector	Max. floor area per detector	Max. distance apart between centres	Max. distance away from bulkheads
Heat	37 $[m]^2$	9 [m]	4.5 [m]
Smoke	74 $[m]^2$	11 [m]	5.5 [m]

9.2.4.3 Arrangement of cables

9.2.4.3.1 Cables which form a part of the system are to be so arranged as to avoid galleys, machinery spaces of category A, and other enclosed spaces of high fire risk except where it is necessary to provide for fire detection or fire alarms in such spaces or to connect to the appropriate power supply.

9.2.4.3.2 A section with individually identifiable capability is not to be damaged at more than one point by a fire.

9.2.5 System control requirements

9.2.5.1 Visual and audible fire signals

(Refer to the Code on alerts and Indicators as adopted by IMO by resolution A.1021(26)).

9.2.5.1.1 The activation of any detector or manually operated call point is to initiate a visual and audible fire detection alarm signal at the control panel and indicating units. If the signals have not received attention within 2 min an audible fire alarm is to be automatically sounded throughout the crew accommodation and service spaces, control stations and machinery spaces of category A. This alarm sounder system need not be an integral part of the detection system.

9.2.5.1.2 In passenger ships, the control panel is to be located in the onboard safety centre. In cargo ships, the control panel is to be located on the navigating bridge or in the control station.

9.2.5.1.3 In passenger ships, an indicating unit that is capable of individually identifying each detector that has been activated or manually operated call point that has operated is to be located on the navigation bridge. In cargo ships and on passenger cabin balconies, indicating units are to as a minimum, denote the section in which a detector or manually operated call point has operated. In ships constructed on or after 1 July 2014, with a cargo control room, an additional indicating unit is to be located in the cargo control room. In cargo ships, an indicating unit is to be located on the navigating bridge if the control panel is located in the fire control station.

IR.9.2.5.1.3 A space in which a cargo control console is installed, but does not serve as a dedicated cargo control room (e.g. ship's office, machinery control room), is to be regarded as a cargo control room in the context of 9.2.5.1.3 and therefore be provided with an additional indicating unit.

9.2.5.1.4 Clear information is to be displayed on or adjacent to each indicating unit about the spaces covered and the location of the sections.

9.2.5.1.5 Power supplies and electric circuits necessary for the operation of the system are to be monitored for loss of power or fault conditions as appropriate including:

.1 a single open or power break fault caused by a broken wire;

.2 a single ground fault caused by the contact of a wiring conductor to a metal component; and

.3 a single wire to wire fault caused by the contact of two or more wiring conductors.

Occurrence of a fault condition is to initiate a visual and audible fault signal at the control panel which is to be distinct from a fire signal.

9.2.5.1.6 Means to manually acknowledge all alarm and fault signals is to be provided at the control panel. The audible alarm sounders on the control panel and indicating units may be manually silenced. The control panel is to clearly distinguish between normal, alarm, acknowledged alarm, fault and silenced conditions.

9.2.5.1.7 The system is to be arranged to automatically reset to the normal operating condition after alarm and fault conditions are cleared.

9.2.5.1.8 When the system is required to sound a local audible alarm within the cabins where the detectors are located, a means to silence the local audible alarms from the control panel is not to be provided.

9.2.5.1.9 In general, audible alarm sound pressure levels at the sleeping positions in the cabins and 1 m from the source are to be at least 75 dB(A) and at least 10 dB(A) above ambient noise levels existing during normal equipment operation with the ship under way in moderate weather. The sound pressure level should be in the 1/3 octave band about the fundamental frequency. Audible alarm signals are not to exceed 120 dB(A).

9.2.5.2 Testing

Suitable instructions and component spares for testing and maintenance are to be provided. Detectors are to be periodically tested using equipment suitable for the types of fires to which the detector is designed to respond. On ships constructed on or after 1 July 2014, detectors installed within cold spaces such as refrigerated compartments are to be tested using procedures having due regard for such locations*. Special consideration will be given to ships with self-diagnostic systems that have in place a documented periodic cleaning procedure for detectors in areas where heads may be prone to contamination.
* Note: Refer to the recommendations of the International Electro-technical Commission, in particular publication IEC 60068-2-1 – Section one -Test Ab, *Environmental Testing – Part 2-1: Tests – Test A: Cold.*"

Section 10

Sample Extraction Smoke Detection Systems

10.1 Application

This section details the specifications for sample extraction smoke detection systems as required by Ch.3, Sec.4.

10.2 Engineering specifications

10.2.1 General requirements

10.2.1.1 Wherever in the text of following requirements the word "system" appears, it means "sample extraction smoke detection system".

10.2.1.1.1 A sample extraction smoke detection system consists of the following main components:

.1 smoke accumulators: air collection devices installed at the open ends of the sampling pipes in each cargo hold that perform the physical function of collecting air samples for transmission to the control panel through the sampling pipes and may also act as discharge nozzles for the fixed-gas fire-extinguishing system, if installed;

.2 sampling pipes: a piping network that connects the smoke accumulators to the control panel, arranged in sections to allow the location of the fire to be readily identified;

.3 three-way valves: if the system is interconnected to a fixed-gas fire-extinguishing system, three-way valves are used to normally align the sampling pipes to the control panel and if a fire is detected, the three-way valves are re-aligned to connect the sampling pipes to the fire-extinguishing system discharge manifold and isolate the control panel; and

.4 control panel: the main element of the system which provides continuous monitoring of the protected spaces for indication of smoke. It typically may include a viewing chamber or smoke sensing units. Extracted air from the protected spaces is drawn through the smoke accumulators and sampling pipes to the viewing chamber and then to the smoke sensing chamber where the air stream is monitored by electrical smoke detectors. If smoke is sensed, the repeater panel (normally on the bridge) automatically sounds an alarm (not localized). The crew can then determine at the smoke sensing unit which cargo hold is on fire and operate the pertinent three-way valve for discharge of the extinguishing agent.

Note : ‘Not localized’ means that the alarm is initiated at control panel as well as repeater panel(s) / indicating unit(s) as given in Cl.10.2.4.1.1.

10.2.1.2 Any required system is to be capable of continuous operation at all times except that systems operating on a sequential scanning principle may be accepted, provided that the interval between scanning the same position twice gives a maximum allowable interval determined as follows:

The interval (I) should depend on the number of scanning points (N) and the response time of the fans (T) (determined by the designer), with a 20% allowance:

$I = 1.2 \times T \times N$

However, the maximum allowable interval is not to exceed 120 s (I_{max} = 120 s).

10.2.1.3 The system is to be designed, constructed and installed so as to prevent the leakage of any toxic or flammable substance or fire-extinguishing media into any accommodation and service space, control station or machinery space.

10.2.1.4 The system and equipment are to be suitably designed to withstand supply voltage variations and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships and to avoid the possibility of ignition of flammable gas/air mixture.

10.2.1.5 The functioning of the system is to be periodically tested to the satisfaction of IRS. The system is to be of a type that can be tested for correct operation and restored to normal surveillance without the renewal of any component.

10.2.1.6 An alternative power supply for the electrical equipment used in the operation of the system is to be provided.

10.2.2 Component requirements

10.2.2.1 The sensing unit is to be certified to operate before the smoke density within the sensing chamber exceeds 6.65 per cent obscuration per metre.

10.2.2.2 Duplicate sample extraction fans are to be provided. The fans are to be of sufficient capacity to operate under normal ventilation conditions in the protected area and the connected pipe size is to be determined with consideration of fan suction capacity and piping arrangement to satisfy the conditions of clause 10.2.4.2.2. Sampling pipes are to be a minimum of 12 [mm] internal diameter. The fan suction capacity is to be adequate to ensure the response of the most remote area within the required time criteria in Cl. 10.2.4.2.2. Means to monitor airflow are to be provided in each sampling line.

10.2.2.3 The control panel is to permit observation of smoke in the individual sampling pipe.

10.2.2.4 Means are to be provided to monitor the airflow through the sampling pipes so designed as to ensure that as far as practicable equal quantities are extracted from each interconnected accumulator.

10.2.2.5 Sampling pipes are to be provided with an arrangement for periodically purging with compressed air.

10.2.2.6 The control panel for the smoke detection system is to be tested according to standards EN 54-2 (1997), EN 54-4 (1997) and IEC 60092-504 (2001). Alternative standards may be accepted by IRS.

10.2.3 Installation requirements

10.2.3.1 Smoke accumulators

10.2.3.1.1 At least one smoke accumulator is to be located in every enclosed space for which smoke detection is required. However, where a space is designed to carry oil or refrigerated cargo alternatively with cargoes for which a smoke sampling system is required, means may be provided to isolate the smoke accumulators in such compartments for the system. Such means are to be to the satisfaction of IRS.

10.2.3.1.2 Smoke accumulators are to be located overhead or as high as possible in the protected space and are to be spaced so that no part of the overhead deck area is more than 12 [m] measured horizontally from an accumulator. Where systems are used in spaces which may be mechanically ventilated, the position of the smoke accumulators is to be considered having regard to the effects of ventilation. At least one additional smoke accumulator is to be provided in the upper part of each exhaust ventilation duct. An adequate filtering system is to be fitted at the additional accumulator to avoid dust contamination.

10.2.3.1.3 Smoke accumulators are to be positioned where impact or physical damage is unlikely to occur.

10.2.3.1.4 Sampling pipe networks are to be balanced to ensure compliance with Cl. 10.2.2.4. The number of accumulators connected to each sampling pipe are to ensure compliance with Cl. 10.2.4.2.2.

10.2.3.1.5 Smoke accumulators from more than one enclosed space are not to be connected to the same sampling point.

10.2.3.1.6 In cargo holds where non-gastight “tween deck panels” (movable stowage platforms) are provided, smoke accumulators are to be located in both the upper and lower parts of the holds.

10.2.3.2 Sampling pipes

10.2.3.2.1 The sampling pipe arrangements are to be such that the location of the fire can be readily identified.

10.2.3.2.2 Sampling pipes are to be self-draining and suitably protected from impact or damage from cargo working.

10.2.4 System control requirements

10.2.4.1 Visual and audible fire signals

10.2.4.1.1 The detection of smoke or other products of combustion is to initiate a visual and audible signal at the control panel and indicating units.

10.2.4.1.2 The control panel is to be located on the navigating bridge or in the fire control station. An indicating unit is to be located on the navigation bridge if the control panel is located in the fire control station.

10.2.4.1.3 Clear information is to be displayed on or adjacent to the control panel designating the spaces covered.

10.2.4.1.4 Power supplies necessary for the operation of the system are to be monitored for loss of power. Any loss of power is to initiate a visual and audible signal at the control panel and the navigating bridge which is to be distinct from a signal indicating smoke detection.

10.2.4.1.5 Means to manually acknowledge all alarm and fault signals are to be provided at the control panel. The audible alarm sounders on the control panel and indicating units may be manually silenced. The control panel is to clearly distinguish between normal, alarm, acknowledged alarm, fault and silenced conditions.

10.2.4.1.6 The system is to be arranged to automatically reset to the normal operating condition after alarm and fault conditions are cleared.

10.2.4.2 Testing

10.2.4.2.1 Suitable instructions and component spares are to be provided for the testing and maintenance of the system.

10.2.4.2.2 After installation, the system is to be functionally tested using smoke generating machines or equivalent as a smoke source. An alarm is to be received at the control unit in not more than 180 s for vehicle decks and not more than 300 s for container and general cargo holds, after smoke is introduced at the most remote accumulator.

Section 11

Low-Location Lighting Systems

11.1 Application

This section details the specifications for low-location lighting systems as required by Ch.4, Sec.2.

11.2 Engineering specifications

11.2.1 General requirements

Any required low-location lighting systems is to be approved based on the requirements of the National Statutory Authority.

(Refer to the Guidelines for the evaluation, testing and application of low-location lighting on passenger ships as adopted by IMO resolution A.752(18)).

(Refer to the Recommendations by the International Organization for Standardization, in particular, publication ISO 15370:2001 on Low-location lighting on passenger ships).

Section 12

Fixed Emergency Fire Pumps

12.1 Application

This section details the specifications for emergency fire pumps as required by Chapter.3. This section is not applicable to passenger ships of 1,000 gross tonnage and upwards. See Ch.3, 4.2.2.3.1.1 for requirements for such ships.

12.2 Engineering specifications

12.2.1 General

12.2.1.1 The emergency fire pump is to be a fixed independently driven power-operated pump.

IR12.2.1.2 The emergency fire pump and its prime mover are to be approved. The emergency fire pump may also be used for other suitable purposes subject to approval in each case.

12.2.2 Component requirements

12.2.2.1 Emergency fire pumps

12.2.2.1.1 Capacity of the pump

.1 The capacity of the pump is not to be less than 40% of the total capacity of the fire pumps required by Ch.3, 4.2.2.4.1 and in any case not less than the following:

.1	for passenger ships less than 1,000 gross tonnage and for cargo ships of 500 gross tonnage and upwards; and	32 [m^3/h]
.2	for cargo ships less than 500 gross tonnage	15 [m^3/h]

IR.2 The emergency fire pump is also to be capable of supplying two jets of water. Where a fixed water-based fire extinguishing system installed for the protection of the machinery space in accordance with Ch.3, Cl.4.4.1.1, is supplied by the emergency fire pump, the emergency fire pump capacity is to be adequate to supply the fixed fire extinguishing system at the required pressure plus two jets of water. The capacity of the two jets is to be calculated for two biggest nozzle sizes on board from the following table (* note):

Capacity required for one jet		
Nozzle size Pressure at hydrant	16 mm	19mm
0.27 [N/mm^2]	16 [m^3/h]	23.5 [m^3/h]

*Note: When selecting the biggest nozzle size onboard, the nozzles located in the space where the main fire pumps are located can be excluded.

IR.3 On board cargo ships designed to carry five or more tiers of containers on or above the weather deck, the total capacity of the emergency fire pump need not exceed 72 [m^3/hr].

12.2.2.1.2 Pressure at hydrants

When the pump is delivering the quantity of water required by 12.2.2.1.1, the pressure at any hydrants is not to be less than the minimum pressure required by Chapter 3.

12.2.2.1.3 Suction heads

.1 The total suction head and the net positive suction head of the pump is to be determined having due regard to the requirements of Chapter 3 and this section on the pump capacity and on the hydrant pressure under all conditions of list, trim, roll and pitch likely to be encountered in service. The ballast condition of a ship on entering or leaving a dry dock need not be considered a service condition.

IR.1

IR.1.1 It is to be documented that the suction inlet is fully submerged under “all conditions of list, trim, roll and pitch likely to be encountered in service” as given below.

IR.1.1.1 Operational seagoing condition for which roll, pitch and heave is to be applied is as follows:

The lightest seagoing condition is to be considered, which is defined as the ballast condition which gives the shallowest draught at the position of the sea chest and emergency fire pump as given in the approved stability booklet (or preliminary stability calculation for new building). The following table is to be applied for the calculation of roll, pitch and heave. The heave combined pitch and heave combined roll are taken into account separately.

IR.1.1.1.1 Heave combined pitch in head sea as given in Fig.12.2.2.1.3

L_{LL} (m)	75 and below	100	125	150	175	200	225	250	300	350 and above
Φ (deg)	4.5	4	3.2	2.7	2.3	2.1	1.8	1.7	1.6	1.5
H (m)	0.73	0.8	0.87	0.93	1.03	1.07	1.11	1.19	1.25	
Note: Values at the intermediate length of ships are to be obtained by linear interpolation.										

Where:

L_{LL}: length of the ship, in meters, as defined in the International Convention on Load Lines in force, or length between perpendiculars at the ballast draught, whichever is greater φ: pitch angle (angle is to be measured from still waterline and downwards) as defined in Fig.12.2.2.1.3

H: heave amplitude as defined in Fig.12.2.2.1.3

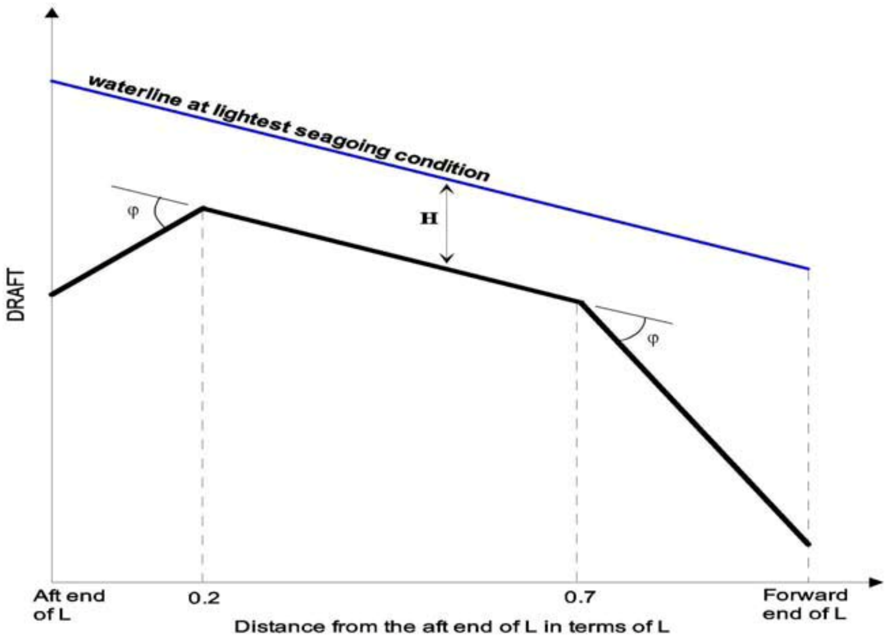


Fig.12.2.2.1.3 : Waterline for which heave combined pitch is taken into account

IR.1.1.1.2 Heave combined roll in beam sea

Heave combined roll angle (angle is to be measured from still waterline and downwards) is to be taken as:

a) ships with bilge keels: 11°; and

b) ships without bilge keels: 13°

IR.1.1.2 The emergency fire pump suction is to be submerged at the waterlines corresponding to the two following conditions:

.1 a static waterline drawn through the level of 2/3 immersion of the propeller at even keel (for pod or thruster driven ship, special consideration will be given); and

.2 the ship in the arrival ballast condition, as per the approved trim and stability booklet, without cargo and with 10% stores and fuel remaining.

For either condition, roll, pitch and heave need not be applied.

The required minimum draught at the sea chest in any condition is to be indicated in the fire fighting system / fire control plans.

IR.1.1.3 A ship operating solely in sheltered water is to be subject to compliance with the still water submergence requirements set out in IR.1.1.2.1 above.

IR.1.2 In all cases the net positive suction head (NPSH) available for the pump is to be greater than the NPSH required.

IR.1.3 Upon completion of the emergency fire pump installation, a performance test confirming the pump's capacity required as per 12.2.2.1.1, is to be carried out and, if the emergency fire pump is the main supply of water for any fixed fire- extinguishing system provided to protect the spaces where the main fire pumps are located, the pump is to have the capacity for this system. As far as practicable, the test is to be carried out at the draught corresponding to the lightest seagoing condition.

IR.2 The pump is to be designed to be of self-priming type and its suction are to be so positioned that the pump will operate efficiently at the lightest draft likely to be encountered in service (as per IR1.1.1. above) having regard to the probable deterioration of the pump and internal growth of corrosion products in suction line.

12.2.2.2 Diesel engines and fuel tank

12.2.2.2.1 Starting of diesel engine

Any diesel driven power source for the pump is to be capable of being readily started in its cold condition down to the temperature of 0°C by hand (manual) cranking. Where ready starting cannot be assured, if this is impracticable, or if lower temperature is likely to be encountered, and if the room for the diesel driven power source is not heated, electric heating of the diesel engine cooling water or lubricating oil system is to be fitted, to the satisfaction of IRS. If hand (manual) starting is impracticable, compressed air, electricity, or other sources of stored energy, including hydraulic power or starting cartridges may be used as a means of starting. These means are to be such as to enable the diesel-driven power source to be started at least six times within a period of 30 min and at least twice within the first 10 min.

12.2.2.2.2 Fuel tank capacity

.1 Any service fuel tank is to contain sufficient fuel to enable the pump to run on full load for at least six hours and sufficient reserves of fuel is to be available outside the machinery space of category A to enable the pump to be run on full load for an additional 15 h. For cargo ships of less than 5000 tons gross, the running time may be reduced to at least three hours.

IR.2 The fuel oil supplying is to be so arranged that it will not readily be affected by a fire in the compartment containing the main fire pumps and preferably located in the same compartment as where emergency fire pump is located.

Section 13

Arrangement of Means of Escape

13.1 Application

This chapter details the specifications for means of escape as required by Chapter 4.

13.2 Passenger ships

13.2.1 Width of stairways

13.2.1.1 Basic requirements for stairway width

Stairways are not to be less than 900 [mm] in clear width. The minimum clear width of stairways is to be increased by 10 mm for every one person provided for in excess of 90 persons. The total number of persons to be evacuated by such stairways is to be assumed to be two thirds of the crew and the total number of passengers in the areas served by such stairways. The width of the stairways is not be inferior to those determined by 13.2.1.2.

13.2.1.2 Calculation method of stairway width

13.2.1.2.1 Basic principles of the calculation

.1 This calculation method determines the minimum stairway width at each deck level, taking into account the consecutive stairways leading into the stairway under consideration.

.2 It is the intention that the calculation method is to consider evacuation from enclosed spaces within each main vertical zone individually and take into account all of the persons using the stairway enclosures in each zone, even if they enter that stairway from another vertical zone.

.3 For each main vertical zone the calculation is to be completed for the night time (case 1) and day time (case 2) and the largest dimension from either case used for determining the stairway width for each deck under consideration.

.4 The calculation of stairway widths are to be based upon the crew and passenger load on each deck. Occupant loads are to be rated by the designer for passenger and crew accommodation spaces, service spaces, control spaces and machinery spaces. For the purpose of the calculation the maximum capacity of a public space is to be defined by either of the following two values:

- the number of seats or similar arrangements, or
- the number obtained by assigning 2 [m^2] of gross deck surface area to each person.

13.2.1.2.2 Calculation method for minimum value

13.2.1.2.2.1 Basic formulae

In considering the design of stairway widths for each individual case which allow for the timely flow of persons evacuating to the muster stations from adjacent decks above and below, the following calculation methods are to be used (See Fig.13.1 and Fig.13.2):

when joining two decks:	$W=(N_1+N_2)$ 10 [mm];
when joining three decks:	$W=(N_1+N_2+0.5N_3)$ 10 [mm];
when joining four decks:	$W=(N_1+N_2+0.5N_3+0.25N_4)$ 10 [mm];
when joining five decks or more decks, the width of the stairways is to be determined by applying the above formula for four decks to the deck under consideration and to the consecutive deck.	

where:

W = the required tread width between handrails of the stairway.

The calculated value of W may be reduced where available landing area S is provided in stairways at the deck level defined by subtracting P from Z, such that:

$P = S \times 3.0$ persons/m^2 ; and $P_{max} = 0.25Z$

where:

Z = the total number of persons expected to be evacuated on the deck being considered;

P = the number of persons taking temporary refuge on the stairway landing, which may be subtracted from Z to a maximum value of P = 0.25Z (to be rounded down to the nearest whole number);

S = the surface area [m^2] of the landing, minus the surface area necessary for the opening of doors and minus the surface area necessary for accessing the flow on stairs (See Fig.13.1);

N = the total number of persons expected to use the stairway from each consecutive deck under consideration; N_1 is for the deck with the largest number of persons using that stairway; N_2 is taken for the deck with the next highest number of persons directly entering the stairway flow such that, when sizing the stairway width as each deck level, $N_1 > N_2 > N_3 > N_4$ (See Fig.13.2). These decks are assumed to be on or upstream (i.e. away from the embarkation deck) of the deck being considered.

Case 1: Passengers in cabins with maximum berthing capacity fully occupied; members of the crew in cabins occupied to 2/3 of maximum berthing capacity; and service spaces occupied by 1/3 of the crew.

Case 2: Passengers in public spaces occupied to 3/4 of maximum capacity; members of the crew in public spaces occupied to 1/3 of the maximum capacity; service spaces occupied by 1/3 of the crew; and crew accommodation occupied by 1/3 of the crew.

13.2.1.2.2.2 Distribution of persons

.1 The dimensions of the means of escape are to be calculated on the basis of the total number of persons expected to escape by the stairway and through doorways, corridors and landings (See Fig.13.3). Calculations are to be made separately for the two cases of occupancy of the spaces specified below. For each component part of the escape route, the dimension taken is not to be less than the largest dimension determined for each case.

.2 The maximum number of persons contained in a vertical zone, including persons entering stairways from another main vertical zone, is not to be assumed to be higher than the maximum number of persons authorized to be carried on board for the calculation of stairway width only.

13.2.1.3 Prohibition of decrease in width in the direction to the assembly station

(Refer to the Indication of the “assembly stations” in passenger ships (MSC/Circ.777)).

The stairway is not to decrease in width in the direction of evacuation to the assembly station, except in the case of several assembly stations in one main vertical zone the stairway width is not to decrease in the direction of the evacuation to the most distant assembly station.

13.2.2 Details of stairways

13.2.2.1 Handrails

Stairways are to be fitted with handrails on each side. The maximum clear width between handrails is to be 1,800 [mm].

13.2.2.2 Alignment of stairways

All stairways sized for more than 90 persons are to be aligned fore and aft.

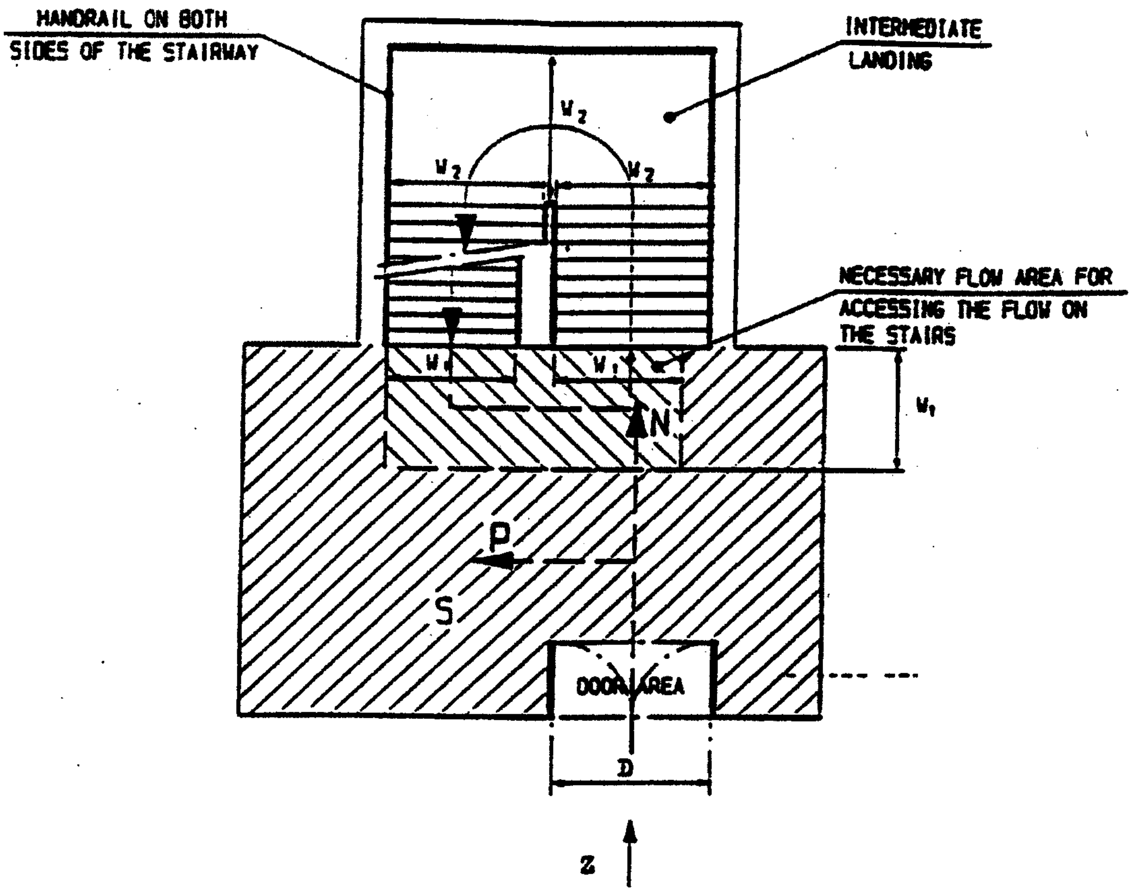


Fig.13.1 : Landing calculation for stairway width reduction

13.2.2.3 Vertical rise and inclination

Stairways are not to exceed 3.5 [m] in vertical rise without the provision of a landing and are not to have an angle of inclination greater than 45°.

13.2.2.4 Landings

With the exception of intermediate landings, landings at each deck level are not to be less than 2 [m^2] in area and is to increase by 1 [m^2] for every 10 persons provided for in excess of 20 persons but need not exceed 16 [m^2], except for those landings servicing public spaces having direct access onto the stairway enclosure. Intermediate landings are to be sized in accordance with 13.2.3.1.

13.2.3 Doorways and corridors

13.2.3.1 Doorways and corridors and intermediate landings included in means of escape are to be sized in the same manner as stairways.

13.2.3.2 The aggregate width of stairway exit doors to the assembly station are not to be less than the aggregate width of stairways serving this deck.

13.2.4 Evacuation routes to the embarkation deck

13.2.4.1 Assembly station

It is to be recognized that the evacuation routes to the embarkation deck may include an assembly station. In this case consideration is to be given to the fire-protection requirements and sizing of corridors and doors from the stairway enclosure to the assembly station and from the assembly station to the embarkation deck, noting that evacuation of persons from assembly stations to embarkation positions are to be carried out in small control groups.

13.2.4.2 Routes from the assembly station to the survival craft embarkation position

Where the passengers and crew are held at an assembly station which is not at the survival craft embarkation position, the dimension of stairway width and doors from the assembly station to this position are not to be based on the number of persons in the controlled group. The width of these stairways and doors need not exceed 1,500 mm unless larger dimensions are required for evacuation of these spaces under normal conditions.

13.2.5 Means of escape plans

13.2.5.1 Means of escape plans are to be provided indicating the following:

.1 the number of the crew and passengers in all normally occupied spaces;

.2 the number of crew and passengers expected to escape by stairway and through doorways, corridors and landings;

.3 assembly stations and survival craft embarkation positions;

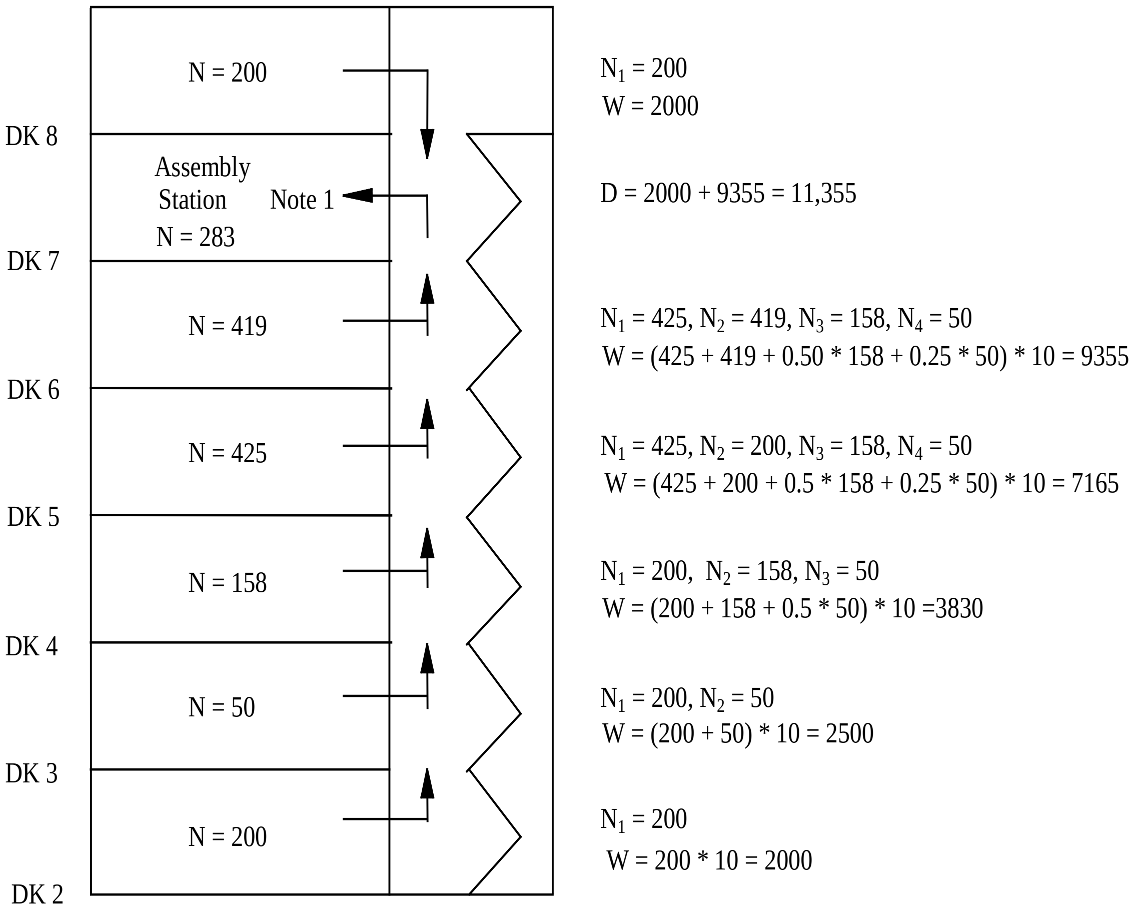
.4 primary and secondary means of escape; and

.5 width of stairways, doors, corridors and landing areas.

13.2.5.2 Means of escape plans are to be accompanied by detailed calculation for determining the width of escape stairways, doors, corridors and landing areas.

13.3 Cargo ships

Stairways and corridors used as means of escape are to be not less than 700 [mm] in clear width and is to have a handrail on one side. Stairways and corridors with a clear width of 1,800 [mm] and over is to have handrails on both sides. “Clear width” is considered the distance between the handrail and the bulkhead on the other side or between the handrails. The angle of inclination of stairways are to be, in general, 45º, but not greater than 50º, and in machinery spaces and small spaces not more than 60º. Doorways which give access to a stairway are to be of the same size as the stairway.



Z(pers)	=	number of persons expected to evacuate through the stairway
N(pers)	=	number of persons directly entering the stairway flow from a given deck
W(mm)	=	$(N_1 + N_2 + 0.5 \times N_3 + 0.25 \times N_4) \times 10$ = calculated width of stairway
D(mm)	=	width of exit doors

$N_1 > N_2 > N_3 > N_4$ where:

N_1(pers)	=	the deck with the largest number of persons N entering directly the stairway
N_2(pers)	=	the deck with the next largest number of persons N entering directly the stairway, etc.

Note 1 : The doors to the assembly station should have aggregate width of 11,355 [mm].

Fig.13.2 : Minimum stairway width (W) calculation example

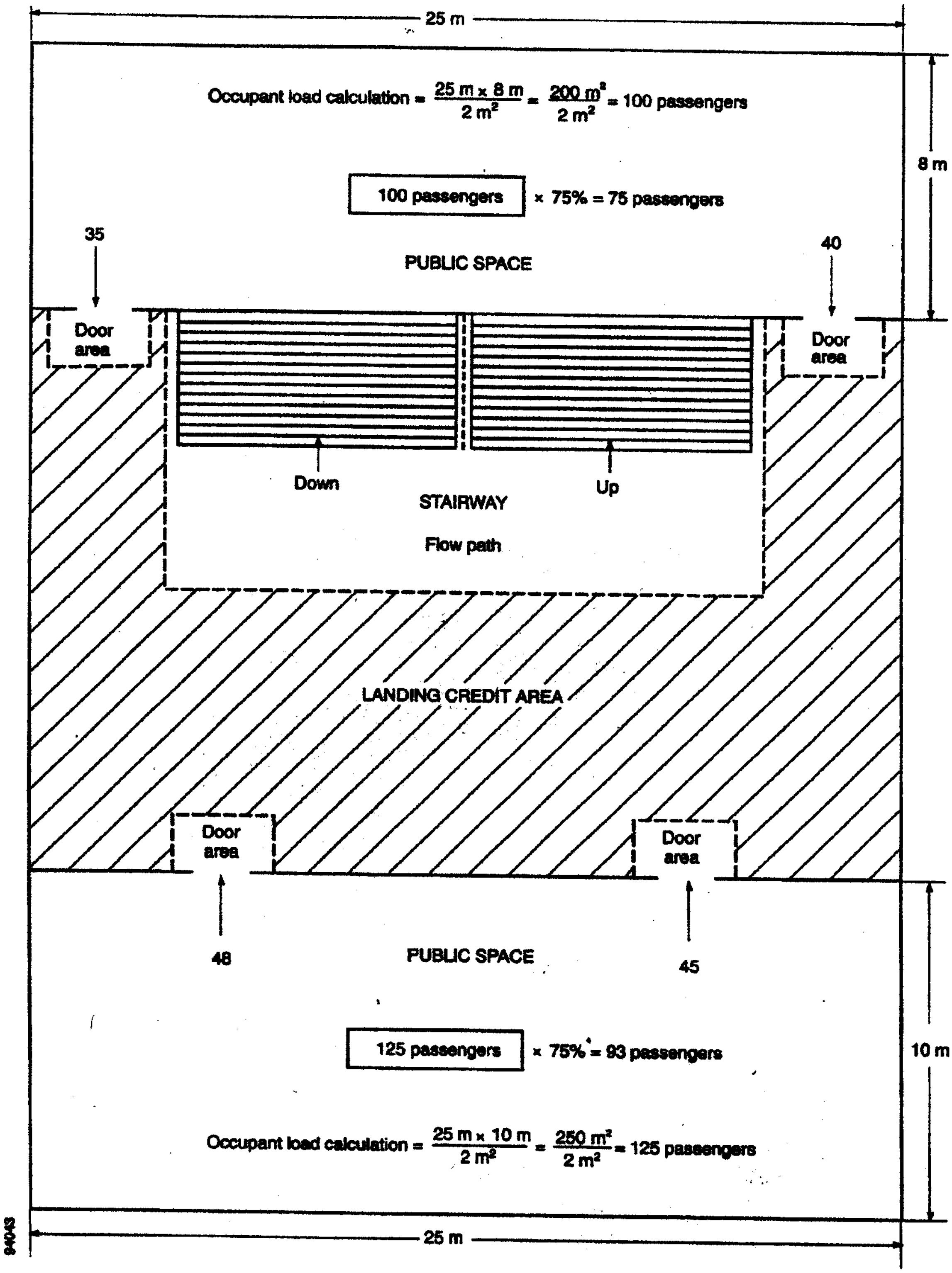


Fig.13.3 : Occupant loading calculation example

Section 14

Fixed Deck Foam Systems

14.1 Application

This section details the specifications for fixed deck foam systems which are required to be provided by Ch.3, Sec.4.

14.2 Engineering specifications

14.2.1 General

14.2.1.1 The arrangements for providing foam are to be capable of delivering foam to the entire cargo tank area as well as into any cargo tank, the deck of which has been ruptured.

14.2.1.2 The deck foam system is to be capable of simple and rapid operation.

14.2.1.3 Operation of a deck foam system at its required output is to permit the simultaneous use of the minimum required number of jets of water at the required pressure from the fire main. Where the deck foam system is supplied by a common line from the fire main, additional foam concentrate is to be provided for operation of two nozzles for the same period of time required for the foam system. The simultaneous use of the minimum required jets of water is to be possible on deck over the full length of the ship, in the accommodation, service spaces, control stations and machinery spaces.

IR14.2.1.3 A common line for fire main and deck foam line can only be considered acceptable provided it can be demonstrated that the hose nozzles can be effectively controlled by one person when supplied from the common line at a pressure needed for operation of the monitors.

The simultaneous use of the minimum required jets of water is to be possible on deck over the full length of the ship in accommodation, service spaces, control stations and machinery spaces.

14.2.2 Component requirements

14.2.2.1 Foam solution and foam concentrate

14.2.2.1.1 For tankers carrying:

.1 crude oil or petroleum products having a flashpoint not exceeding 60ºC (closed cup), as determined by an approved flashpoint apparatus, and a Reid vapour pressure which is below atmospheric pressure or other liquid products having a similar fire hazard, including cargoes in chapter 18 of the IBC Code, having a flashpoint not exceeding 60ºC (closed cup) for which a regular foam fire-fighting system is effective or

.2 petroleum products with a flashpoint exceeding 60ºC (closed cup), as determined by an approved flashpoint apparatus or

.3 IBC Code chapter 17 products with a flashpoint exceeding 60^{o}C (closed cup) determined by an approved flashpoint apparatus.

The rate of supply of foam solution is not to be less than the greatest of the following :

a) 0.6 [litre/minute/m^2] of cargo deck area, where the cargo deck area means the maximum breadth of the ship multiplied by the total longitudinal extent of the cargo tank spaces;

b) 6 [litres/minute/m^2] of the horizontal sectional area of the single tank having the largest such area; or

c) 3 [litres/minute/m^2] of the area protected by the largest monitor, such area being entirely forward of the monitor, but not less than 1250 litre/minute.

14.2.2.1.2 For tankers carrying chemicals in bulk listed in chapter 17 of the IBC Code having a flashpoint not exceeding 60ºC (closed cup), the rate of supply of foam solution is to be as required by the IBC Code.

14.2.2.1.3 Sufficient foam concentrate is to be supplied to ensure at least 20 min of foam generation in tankers fitted with an inert gas installation or 30 min of foam generation in tankers not fitted with an inert gas installation or not required to use an inert gas system.

14.2.2.1.4 The foam concentrate supplied on board is to be approved* by IRS for the cargoes intended to be carried. Type B foam concentrates are to be supplied for the protection of crude oil, petroleum products and non-polar solvent cargoes. Type A foam concentrates are to be supplied for polar solvent cargoes, as listed in the table of chapter 17 of the IBC Code. Only one type of foam concentrate is to be supplied, and it is to be effective for the maximum possible number of cargoes intended to be carried. For cargoes for which foam is not effective or is incompatible, additional arrangements to the satisfaction of IRS is to be provided.

* Refer to the Guidelines for performance and testing criteria and surveys of foam concentrates for fixed fire-extinguishing systems (MSC.1/Circ.1312).

14.2.2.1.5 Liquid cargoes with a flashpoint not exceeding 60^{o}C for which a regular foam fire-fighting system is not effective are to comply with Pt.6, Ch.1, Sec.1.5.2.1.

14.2.2.2 Monitors and foam applicators

14.2.2.2.1 Foam from the fixed foam system is to be supplied by means of monitors and foam applicators. Prototype tests of the monitors and foam applicators shall be performed to ensure the foam expansion and drainage time of the foam produced does not differ more than ± 10 per cent of that determined in paragraph 14.2.2.1.4. When medium expansion ratio foam (between 21 to 1 and 200 to 1 expansion ratio) is employed, the application rate of the foam and the capacity of a monitor installation is to be to the satisfaction of IRS. At least 50% of the foam solution supply rate required is to be delivered from each monitor. On tankers of less than 4,000 tonnes deadweight only applicators may be provided and monitors may not be required. Use of the capacity of each applicator is to be at least 25% of the foam solution required supply rate.

IR14.2.2.2.1 The requirements given in 14.2.2.2.3 and 14.2.3.3 apply to all tankers regardless of deadweight.

14.2.2.2.2 The capacity of any applicator is to be not less than 400 l/min and the applicator throw in still air conditions is to be not less than 15 [m].

14.2.3 Installation requirements

14.2.3.1 Main control station

The main control station for the system is to be suitably located outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected.

14.2.3.2 Monitors

14.2.3.2.1 The number and position of monitors are to be such as to comply with 14.2.1.1.

14.2.3.2.2 The distance from the monitor to the farthest extremity of the protected area forward of that monitor is not to be more than 75per cent of the monitor throw in still air conditions.

14.2.3.2.3 A monitor and hose connection for a foam applicator are to be situated both port and starboard at the poop front or accommodation spaces facing the cargo deck. These monitors may be located in cargo area as defined in Ch.1, Sec.3 provided they are aft of cargo tanks and that they protect the areas below and aft of each other. On tankers of less than 4,000 tonnes deadweight a hose connection for a foam applicator is to be situated both port and starboard at the front of the poop or accommodation spaces facing the cargo deck.

14.2.3.3 Applicators

14.2.3.3.1 The number of foam applicators provided are to be not less than four. The number and disposition of foam main outlets is to be such that foam from at least two applicators can be directed on to any part of the cargo tanks deck area.

14.2.3.3.2 Applicators are to be provided to ensure flexibility of action during fire-fighting operations and to cover areas screened from the monitors.

14.2.3.4 Isolation valves

Valves are to be provided in both the foam main and fire main when this is an integral part of the deck foam system, immediately forward of every monitor position to isolate damaged sections of those mains.

Section 15

Inert Gas Systems

15.1 Application

This Section details the specifications for inert gas systems as required by Ch.2, 1.5.5.

15.2 Engineering specifications

15.2.1 Definitions

For the purposes of this Section:

15.2.1.1 *Cargo tanks* means those cargo tanks, including slop tanks, which carry cargoes, or cargo residues, having a flashpoint not exceeding 60ºC.

15.2.1.2 *Inert gas system* includes inert gas systems using flue gas, inert gas generators, and nitrogen generators and means the inert gas plant and inert gas distribution together with means for preventing backflow of cargo gases to machinery spaces, fixed and portable measuring instruments and control devices.

15.2.1.3 *Gas-safe space* is a space in which the entry of gases would produce hazards with regard to flammability or toxicity.

15.2.1.4 *Gas-free* is a condition in a tank where the content of hydrocarbon or other flammable vapour is less than 1% of the lower flammable limit (LFL), the oxygen content is at least 21%, by volume and no toxic gases are present. Refer to the *Revised recommendations for entering enclosed spaces aboard ships* (Resolution A.1050(27)).

15.2.2 Requirements for all Systems

15.2.2.1 General

15.2.2.1.1 The inert gas system referred to in Chapter 2 is to be designed, constructed and tested to the satisfaction of IRS. It is to be so designed and operated as to render and maintain the atmosphere of the cargo tanks non-flammable.

IR 15.2.2.1.1 Plans in diagrammatic form are to be submitted for appraisal and are to include the following:

- Details and arrangement of the inert gas generating plant including all control and monitoring devices;
- Arrangement of the piping system for distribution of the inert gas.

(Refer to the revised standards for the design, testing and locating of devices to prevent the passage of flame into cargo tanks in tankers (MSC/Circ.677, as amended by MSC/Circ.1009 and MSC.1/Circ. 1324) and the Revised factors to be taking into consideration when designing cargo tank venting and gas-freeing arrangements (MSC/Circ.731)).

15.2.2.1.2 The system is to be capable of:

.1 inerting empty cargo tanks and maintaining the atmosphere in any part of the tank with an oxygen content not exceeding 8% by volume and at a positive pressure in port and at sea except when it is necessary for such a tank to be gas-free;

.2 eliminating the need for air to enter a tank during normal operations except when it is necessary for such a tank to be gas-free;

.3 purging empty cargo tanks of hydrocarbon or other flammable vapours, so that subsequent gas-freeing operations will at no time create a flammable atmosphere within the tank;

.4 delivering inert gas to the cargo tanks at a rate of at least 125% of the maximum rate of discharge capacity of the ship expressed as a volume. For chemical tankers and chemical/ product tankers, IRS may accept inert gas systems having a lower delivery capacity provided that the maximum rate of discharge of cargoes from cargo tanks being protected by the system is restricted to not more than 80% of the inert gas capacity; and

.5 delivering inert gas with an oxygen content of not more than 5% by volume to the cargo tanks at any required rate of flow.

15.2.2.1.3 Materials used in inert gas systems are to be suitable for their intended purpose. In particular, those components which may be subjected to corrosive action of the gases and/ or liquids are to be either constructed of corrosion-resistant material or lined with rubber, glass fibre epoxy resin or other equivalent coating material.

15.2.2.1.4 The inert gas supply may be:

.1 treated flue gas from main or auxiliary boilers, or

.2 gas from an oil or gas-fired gas generator, or

.3 gas from nitrogen generators.

IRS may accept systems using inert gases from one or more separate gas generators or other sources or any combination thereof, provided that an equivalent level of safety is achieved. Such systems are to, as far as practicable; comply with the requirements of this Section. Systems using stored carbon dioxide are not to be used unless IRS is satisfied that the risk of ignition from generation of static electricity by the system itself is minimized.

IR 15.2.2.1.4 In all cases, automatic control capable of producing suitable inert gas under all service conditions, is to be fitted.

15.2.2.2 Safety Measures

.1 The inert gas system is to be so designed that the maximum pressure which it can exert on any cargo tank will not exceed the test pressure of any cargo tank.

.2 Automatic shutdown of the inert gas system and its components parts are to be arranged on predetermined limits being reached, taking into account the provisions of paragraphs 15.2.2.4, 15.2.3.2 and 15.2.4.2.

.3 Suitable shutoff arrangements are to be provided on the discharge outlet of each generator plant.

.4 The system is to be designed to ensure that if the oxygen content exceeds 5% by volume, the inert gas shall be automatically vented to atmosphere.

.5 Arrangements are to be provided to enable the functioning of the inert gas plant to be stabilized before commencing cargo discharge. If blowers are to be used for gas-freeing, their air inlets are to be provided with blanking arrangements.

.6 Where a double block and bleed valve is installed, the system is to ensure that, upon loss of power, the block valves are automatically closed and the bleed valve is automatically open.

15.2.2.3 System Components

15.2.2.3.1 Non-Return Devices

.1 At least two non-return devices are to be fitted in order to prevent the return of vapour and liquid to the inert gas plant, or to any gas-safe spaces.

.2 The first non-return device is to be a deck seal of the wet, semi-wet, or dry type or a double-block and bleed arrangement given in Pt. 5,Ch. 3, 21.1.2. Two shut-off valves in series with a venting valve in between, may be accepted by IRS provided:

.1 the operation of the valve is automatically executed. Signal(s) for opening/closing is (are) to be taken from the process directly, e.g. inert gas flow or differential pressure; and

.2 alarm for faulty operation of the valves is provided, e.g. the operation status of "blower stop" and "supply valve(s) open" is an alarm condition.

.3 The second non-return device is to be a non-return valve or equivalent capable of preventing the return of vapours and liquids and fitted between the deck water seal (or equivalent device) and the first connection from the inert gas main to a cargo tank. It is to be provided with positive means of closure. As an alternative to positive means of closure, an additional valve having such means of closure may be provided between the non-return valve and the first connection to the cargo tanks to isolate the deck water seal, or equivalent device, from the inert gas main to the cargo tanks.

.4 A water seal, if fitted, is to be capable of being supplied by two separate pumps, each of which shall be capable of maintaining an adequate supply at all times. The audible and visual alarm on the low level of water in the water seal are to operate at all times.

.5 The arrangement of the water seal, or equivalent devices, and its associated fittings is to be such that it will prevent backflow of vapours and liquids and will ensure the proper functioning of the seal under operating conditions.

.6 Provision is to be made to ensure that the water seal is protected against freezing, in such a way that the integrity of seal is not impaired by overheating.

.7 A water loop or other approved arrangement is also to be fitted to each associated water supply and drain pipe and each venting or pressure-sensing pipe leading to gas-safe spaces. Means are to be provided to prevent such loops from being emptied by vacuum.

.8 Any water seal, or equivalent device, and loop arrangements are to be capable of preventing return of vapours and liquids to an inert gas plant at a pressure equal to the test pressure of the cargo tanks.

.9 The non-return devices are to be located in the cargo area on deck.

15.2.2.3.2 Inert Gas Lines

.1 The inert gas main may be divided into two or more branches forward of the non-return devices required by 15.2.2.3.1.

.2 The inert gas main is to be fitted with branch piping leading to the cargo tank. Branch piping for inert gas is to be fitted with either stop valves or equivalent means of control for isolating each tank. Where stop valves are fitted, they are to be provided with locking arrangements. The control system is to provide unambiguous information of the operational status of such valves to at least the control panel required in paragraph 15.2.2.4.

.3 Each cargo tank not being inerted is to be capable of being separated from the inert gas main by:

> .1 removing spool-pieces, valves or other pipe sections, and blanking the pipe ends; or
>
> .2 arrangement of two spectacle flanges in series with provisions for detecting leakage into the pipe between the two spectacle flanges; or
>
> .3 equivalent arrangements to the satisfaction of IRS, providing at least the same level of protection.

.4 Means are to be provided to protect cargo tanks against the effect of overpressure or vacuum caused by thermal variations and/ or cargo operations when the cargo tanks are isolated from the inert gas mains.

.5 Piping systems are to be so designed as to prevent the accumulation of cargo or water in the pipelines under all normal conditions.

.6 Arrangements are to be provided to enable the inert gas main to be connected to an external supply of inert gas. The arrangements are to consist of a 250 [mm] nominal pipe size bolted flange, isolated from the inert gas main by a valve and located forward of the non-return valve. The design of the flange is to conform to the appropriate class in the standards adopted for the design of other external connections in the ship's cargo piping system.

.7 If a connection is fitted between the inert gas main and the cargo piping system, arrangements are to be made to ensure an effective isolation having regard to the large pressure difference which may exist between the systems. This is to consist of two shutoff valves with an arrangement to vent the space between the valves in a safe manner or an arrangement consisting of a spool-piece with associated blanks.

.8 The valve separating the inert gas main from the cargo main and which is on the cargo main side is to be a non-return valve with a positive means of closure.

.9 Inert gas piping systems are not to pass through accommodation, service and control station spaces.

.10 In combination carriers, the arrangement to isolate the slop tanks containing oil or oil residues from other tanks is to consist of blank flanges which will remain in position at all times when cargoes other than oil are being carried except may be accepted by the National Statutory Authority (Refer to the revised guidelines for inert gas systems (MSC/Circ.353), as amended by MSC/Circ.387).

15.2.2.4 Indicators and Alarms

15.2.2.4.1 The operation status of the inert gas system is to be indicated in a control panel.

15.2.2.4.2 Instrumentation is to be fitted for continuously indicating and permanently recording, when inert gas is being supplied:

> .1 the pressure of the inert gas mains forward of the non-return devices; and
>
> .2 the oxygen content of the inert gas.

15.2.2.4.3 The indicating and recording devices are to be placed in the cargo control room where provided. But where no cargo control room is provided, they are to be placed in a position easily accessible to the officer in charge of cargo operations.

15.2.2.4.4 In addition, meters are to be fitted:

.1 in the navigating bridge to indicate at all times the pressure referred to in 15.2.2.4.2.1 and the pressure in the slop tanks of combination carriers, whenever those tanks are isolated from the inert gas main; and

.2 in the machinery control room or in the machinery space to indicate the oxygen content referred to in paragraph 15.2.2.4.2.2.

15.2.2.4.5 Audible and visual alarms

.1 Audible and visual alarms are to be provided, based on the system designed, to indicate:

.1 oxygen content in excess of 5% by volume;

.2 failure of the power supply to the indicating devices as referred to in paragraph 15.2.2.4.2;

.3 gas pressure less than 100 [mm] water gauge. The alarm arrangement is to be such as to ensure that the pressure in slop tanks in combination carriers can be monitored at all times;

.4 high-gas pressure; and

.5 failure of the power supply to the automatic control system

.2 The alarms required in 15.2.2.4.5.1.1, 15.2.2.4.5.1.3 and 15.2.2.4.5.1.5 are to be fitted in the machinery space and cargo control room, where provided, but in each case in such a position that they are immediately received by responsible members of the crew.

.3 An audible alarm system independent of that required in 15.2.2.4.5.1.3 or automatic shutdown of cargo pumps are to be provided to operate on predetermined limits of low pressure in the inert gas main being reached.

.4 Two oxygen sensors are to be positioned at appropriate locations in the space or spaces containing the inert gas system. If the oxygen level falls below 19.5%, these sensors are to trigger alarms, which are to be both visible and audible inside and outside the space or spaces and are to be placed in such a position that they are immediately received by responsible members of the crew.

15.2.2.5 Instruction Manuals

.1 Detailed instruction manuals are to be provided on board, covering the operations, safety and maintenance requirements and occupational health hazards relevant to the inert gas system and its application to the cargo tank system. The manuals are to include guidance on procedures to be followed in the event of a fault or failure of the inert gas system (Refer to the revised guidelines for inert gas systems (MSC/Circ.353), as amended by MSC/Circ.387).

15.2.3 Requirements for flue gas and inert gas generators systems

In addition to the provisions in 15.2.2, for inert gas systems using flue gas or inert gas generators, the provisions of this sub-section shall apply.

15.2.3.1 System requirements

15.2.3.1.1 Inert Gas Generators

.1 Two fuel oil pumps are to be fitted to the inert gas generator. Suitable fuel in sufficient quantity is to be provided for the inert gas generators.

.2 The inert gas generators are to be located outside the cargo tank area. Spaces containing inert gas generators are to have no direct access to accommodation service or control station spaces, but may be located in machinery spaces. If they are not located in machinery spaces, such a compartment is to be separated by a gastight steel bulkhead and/ or deck from accommodation, service and control station spaces. Adequate positive-pressure-type mechanical ventilation is to be provided for such a compartment.

15.2.3.1.2 Gas Regulating Valves

.1 A gas regulating valve is to be fitted in the inert gas main. This valve is to be automatically controlled to close, as required in 15.2.2.2.2. It is also to be capable of automatically regulating the flow of inert gas to the cargo tanks unless means are provided to automatically control the inert gas flow rate.

.2 The gas regulating valve is to be located at the forward bulkhead of the forward most gas-safe space through which the inert gas main passes.

15.2.3.1.3 Cooling and Scrubbing Arrangement

.1 Means are to be fitted which will effectively cool the volume of gas specified in 15.2.2.1.2 and remove solids and sulphur combustion products. The cooling water arrangements are to be such that an adequate supply of water will always be available without interfering with any essential services on the ship. Provision is also to be made for an alternative supply of cooling water.

.2 Filters or equivalent devices are to be fitted to minimize the amount of water carried over to the inert gas blowers.

15.2.3.1.4 Blowers

.1 At least two inert gas blowers are to be fitted and be capable of delivering to the cargo tanks at least the volume of gas required by 15.2.2.1.2. For systems fitted with inert gas generators one blower only may be accepted if that system is capable of delivering the total volume of gas required by 15.2.2.1.2 to the cargo tanks, provided that sufficient spares for the blower and its prime mover are carried on board to enable any failure of the blower and its prime mover to be rectified by the ship's crew.

.2 Where inert gas generators are served by positive displacement blowers, a pressure relief device is to be provided to prevent excess pressure being developed on the discharge side of the blower.

.3 When two blowers are provided, the total required capacity of the inert gas system is to be divided evenly between the two and in no case is one blower to have a capacity less than 1/3 of the total capacity required.

15.2.3.1.5 Inert gas isolating valves

.1 For systems using flue gas, flue gas isolating valves are to be fitted in the inert gas mains between the boiler uptakes and the flue gas scrubber. These valves are to be provided with indicators to show whether they are open or shut, and precautions are to be taken to maintain them gastight and keep the seatings clear of soot. Arrangements are to be made to ensure that boiler soot blowers cannot be operated when the corresponding flue gas valve is open.

15.2.3.1.6 Prevention of flue gas leakage

.1 Special consideration is to be given to the design and location of scrubber and blowers with relevant piping and fittings in order to prevent flue gas leakages into enclosed spaces.

.2 To permit safe maintenance, an additional water seal or other effective means of preventing flue gas leakage are to be fitted between the flue gas isolating valves and scrubber or incorporated in the gas entry to the scrubber.

15.2.3.2 Indicators and Alarms

.1 To permit safe maintenance, an additional water seal or other effective means of preventing flue gas leakage is to be fitted between the flue gas isolating valves and scrubber or incorporated in the gas entry to the scrubber.

.2 In addition to the requirements of 15.2.2.4.5, audible and visual alarms are to be provided to indicate:

.1 insufficient fuel oil supply to the oil-fired inert gas generator;

.2 failure of the power supply to the generator;

.3 low water pressure or low water flow rate to the cooling and scrubbing arrangement;

.4 high water level in the cooling and scrubbing arrangement;

.5 high gas temperature;

.6 failure of the inert gas blowers; and

.7 low water level in the water seal.

15.2.4 Requirements for Nitrogen Generator Systems

The provisions of this section shall apply, in addition to the provisions in 15.2.2, for inert gas systems using nitrogen generators.

15.2.4.1 System Requirements

.1 The system is to be provided with one or more compressors to generate enough positive pressure to be capable of delivering the total volume of gas required by 15.2.2.1.2.

.2 A feed air treatment system is to be fitted to remove free water, particles and traces of oil from the compressed air.

.3 The air compressor and nitrogen generator may be installed in the engine-room or in a separate compartment. A separate compartment and any installed equipment are to be treated as an "Other machinery space" with respect to fire protection. Where a separate compartment is provided for the nitrogen generator, the compartment is to be fitted with an independent mechanical extraction ventilation system providing six air changes per hour. The compartment is to have no direct access to accommodation spaces, service spaces and control stations.

Note : Supply air requirement should take into account the need for the nitrogen generator system as well as for the compartment ventilation.

.4 Where a nitrogen receiver or a buffer tank is installed, it may be installed in a dedicated compartment, in a separate compartment containing the air compressor and the generator, in the engine room, or in the cargo area. Where the nitrogen receiver or a buffer tank is installed in an enclosed space, the access is to be arranged only from the open deck and the access door is to open outwards. Adequate, independent mechanical ventilation, of the extraction type, is to be provided for such a compartment.

.5 In order to permit maintenance, means of isolation are to be fitted between the generator and the receiver.

.IR.5 In addition to the requirements of this sub-section, the nitrogen generator system is to comply with the requirements of Pt. 5, Ch. 2, Sec. 8 and Pt. 5, Ch. 2,11.3.5 as applicable.

IR.6 The nitrogen generator is to be capable of delivering high purity nitrogen in accordance with 15.2.2.1.2.5. In addition to the requirements of 15.2.2.2.4, the system is to be fitted with automatic means to discharge ‘off-spec’ gas to the atmosphere during start-up and abnormal operation.

IR.7 Where two compressors are provided, the total required capacity of the system is preferably to be divided equally between the two compressors, and in no case is one compressor to have a capacity less than 1/3 of the total capacity required.

IR.8 The feed air treatment system referred in 15.2.4.1.2 is also required to preserve the specification temperature.

IR.9 The oxygen-enriched air from the nitrogen generator and the nitrogen-product enriched gas from the protective devices of the nitrogen receiver are to be discharged to a “safe location” on the open deck.

IR.10 The “safe location” referred in 15.2.4.1.11 needs to address the two types of discharges separately:

(a) oxygen-enriched air from the nitrogen generator - safe locations on the open deck are:
- outside of hazardous area;
- not within 3 [m] of areas traversed by personnel; and
- not within 6 [m] of air intakes for machinery (engines and boilers) and all ventilation inlets.

(b) nitrogen-product enriched gas from the protective devices of the nitrogen receiver - safe locations on the open deck are:
- not within 3 [m] of areas traversed by personnel; and
- not within 6 [m] of air intakes for machinery (engines and boilers) and all ventilation inlets/outlets.

15.2.4.2 Indicators and Alarms

.1 In addition to the requirements in 15.2.2.4.2, instrumentation is to be provided for continuously indicating the temperature and pressure of air at the suction side of the nitrogen generator.

.2 In addition to the requirements in 15.2.2.4.5, audible and visual alarms are to be provided to include:

.1 failure of the electric heater, if fitted;

.2 low feed-air pressure or flow from the compressor;

.3 high-air temperature; and

.4 high condensate level at automatic drain of water separator.

IR15.2.5 Nitrogen/ Inert Gas Systems Fitted for Purposes other than Inerting required by Ch.2, 1.5.5

IR15.2.5.1 These requirements are applicable to systems fitted on oil tankers, gas tankers or chemical carriers to which requirements of Ch. 2, 1.5.5 do not apply.

15.2.5.2 Paragraphs 15.2.2.2.2, 15.2.2.2.4, 15.2.2.4.2, 15.2.2.4.3, 15.2.2.4.5.1.1, 15.2.2.4.5.1.2, 15.2.2.4.5.4, 15.2.4.1.1, 15.2.4.1.2, 15.2.4.1.3, 15.2.4.1.4, 15.2.4.1.8, 15.2.4.1.10, 15.2.4.1.11, 15.2.4.1.12, 15.2.4.1.13, 15.2.4.2.1 and 15.2.4.2.2 of this Section apply to these systems, as applicable.

IR15.2.5.3 Paragraphs 15.2.4.1.5, 15.2.4.1.6, 15.2.4.1.7, 15.2.4.1.9 are not applicable to these systems.

IR15.2.5.4 All the equipment is to be installed and tested onboard to the satisfaction of the Surveyor.

IR15.2.5.5 The two non-return devices as required by 15.2.2.3.1.1, are to be fitted in the inert gas main. The non-return devices are to comply with 15.2.2.3.1.2 and 15.2.2.3.1.3; however, where the connections to the cargo tanks, to the hold spaces or to cargo piping are not permanent, the non-return devices required by 15.2.2.3.1.1 may be substituted by two non-return valves.

Section 16

Fixed Hydrocarbon Gas Detection Systems

16.1 Application

16.1.1 This section details the specifications for fixed hydrocarbon gas detection systems required by this part of the Rules.

16.1.2 A combined gas detection system required by Ch.2, 1.5.7.3 (requirement for fixed gas detection system in double hull and bottom spaces) and 1.5.10 (condition monitoring in cargo pump rooms) may be accepted in cases where the system fully complies with the requirement of Ch.1, Sec.2.

16.2 Engineering specifications

16.2.1 General

16.2.1.1 The fixed hydrocarbon gas detection system referred to in this part of the Rules is to be designed, constructed and tested to the satisfaction of IRS based on performance standards developed by IMO*.

* Refer to the Guidelines for the design, construction and testing of fixed hydrocarbon gas detection system (MSC.1/Circ.1370).

16.2.1.2 The system is to be comprised of a central unit for gas measurement and analysis and gas sampling pipes in all ballast tanks and void spaces of double-hull and double-bottom spaces adjacent to the cargo tanks, including the forepeak tank and any other tanks and spaces under the bulkhead deck adjacent to cargo tanks.

16.2.1.3 The system may be integrated with the cargo pump-room gas detection system, provided that the spaces referred to in Cl. 16.2.1.2 are sampled at the rate required in Cl. 16.2.2.3.1. Continuous sampling from other locations may also be considered provided the sampling rate is complied with.

16.2.2 Component requirements

16.2.2.1 Gas sampling lines

16.2.2.1.1 The detection equipment is not to be fitted with common sampling lines except the lines serving each pair of sampling points as required in Cl. 16.2.2.1.3.

16.2.2.1.2 The materials of construction and the dimensions of gas sampling lines are to be such as to prevent restriction. Where non-metallic materials are used, they are to be electrically conductive. The gas sampling lines are not to be made of aluminium.

16.2.2.1.3 The configuration of gas sampling lines is to be adapted to the design and size of each space. Except as provided in Cl. 16.2.2.1.4 and 16.2.2.1.5, the sampling system is to allow for a minimum of two hydrocarbon gas sampling points, one located on the lower and one on the upper part where sampling is required. When the upper gas sampling point is required, it is not to be located lower than 1 [m] from the tank top. The position of the lower gas sampling point is to be above the height of the girder of bottom shell plating but at least 0.5 [m] from the bottom of the tank and it is to be provided with means to be closed when clogged (for maintenance). In positioning the fixed sampling points, due regard is also to be given to the density of vapours of the oil products intended to be transported and the dilution from space purging or ventilation.

16.2.2.1.4 For ships with deadweight of less than 50,000 tonnes, IRS may allow the installation of one sampling location for each tank for practical and/or operational reasons.

16.2.2.1.5 For ballast tanks in the double bottom, not intended to be partially filled and for void spaces, the upper gas sampling point is not required.

16.2.2.1.6 Means are to be provided to prevent gas sampling lines from clogging when tanks are ballasted by using compressed air flushing to clean the line after switching from ballast to cargo loaded mode. The system is to have an alarm to indicate if the gas sampling lines are clogged.

16.2.2.2 Gas analysis unit

16.2.2.2.1 The gas analysis unit is to be located in a safe space and is to be located in areas outside the ship's cargo area; for example, in the cargo control room and/or navigation bridge or in the hydraulic room when mounted on the forward bulkhead of the cargo area provided the following requirements are observed:

.1 sampling lines are not to run through gas safe spaces, except where permitted under .5 below;

.2 the hydrocarbon gas sampling pipes are to be equipped with flame arresters. Sample hydrocarbon gas is to be led to the atmosphere with outlets arranged in a safe location, not close to a source of ignitions and not close to the accommodation area air intakes;

.3 a manual isolating valve, which is easily accessible for operation and maintenance is to be fitted in each of the sampling lines at the bulkhead on the gas safety side;

.4 the hydrocarbon gas detection equipment including sample piping, sample pumps, solenoids, analyzing units etc. is to be located in a reasonably gas-tight cabinet (e.g. fully enclosed steel cabinet with a door with gaskets) which is to be monitored by its own sampling point. At a gas concentration above 30% of the lower flammable limit inside the steel enclosure the entire gas analysing unit is to be automatically shut down; and

.5 where the enclosure cannot be arranged directly on the bulkhead, sample pipes from the boundary bulkhead of cargo area are to be of steel or other equivalent material and without detachable connections, except for the connection points for isolating valves at the bulkhead and analyzing unit and are to be as short as possible.

16.2.2.3 Gas detection equipment

16.2.2.3.1 The gas detection equipment is to be designed to sample and analyse from each sampling line of each protected space, sequentially at intervals not exceeding 30 min.

16.2.2.3.2 Means are to be provided to enable measurements with portable instruments, in case the fixed system is out of order or for system calibration. In case the system is out of order, procedures are to be in place to continue to monitor the atmosphere with portable instruments and to record the measurement results.

16.2.2.3.3 Audible and visual alarms are to be initiated in the cargo control room, navigation bridge and at the analyzing unit when the vapour concentration in a given space reaches a pre-set value, which is not be higher than the equivalent of 30% of the lower flammable limit.

16.2.2.3.4 The gas detection equipment is to be so designed that it may readily be tested and calibrated.

End of Chapter