

Guidelines on
**Alternative and Risk based
Design Evaluation**

2019



IRCLASS
Indian Register of Shipping

**Guidelines
on
Alternative and Risk based Design Evaluation
2019**

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Section 1

Introduction

Prescriptive regulations may sometimes restrain the level of innovation that is feasible in design. An essential prerequisite for widespread use of innovative and the use of alternative and/or equivalent design is a reliable, transparent and reproducible process of submitting and approving the design making full use of state of the art risk assessment tools and techniques.

Currently, there are provisions in IRS publications such as Rules, Classification Notes and Guidelines to possible acceptance of alternatives/equivalents in lieu of the prescriptive requirements. Further, there are statutory requirements (e.g. subdivision & stability, fire safety, lifesaving appliances etc.) where alternative arrangements are acceptable provided that an equivalent level of safety is demonstrated.

These guidelines have been prepared with an aim to provide guidance to ship owners, shipyards and ship designers on the procedures to be followed, analyses to be performed, acceptance criteria to be established and documentation to be submitted to IRS for alternative designs/ arrangements in lieu of prescriptive requirements. This would enable IRS to consider the same in lieu of prescriptive requirements within its Rules or for statutory matters in its capacity as a Recognized Organization on the behalf of a flag Administration.

The present guidelines may also be utilized for vessels of a novel configuration or with novel functions & equipment which may not be addressed by the extant IRS Rules.

Section 2

General

2.1 Application and Scope

2.1.1 These guidelines are applicable to all Ships eligible for classification in accordance with IRS Rules including Ships of novel design & configuration.

2.1.2 For alternative designs where IMO/ statutory requirements are also involved, approval for equivalence would also be required from the Flag Administration.

2.1.3 For alternative designs, IRS will issue the Class notation **ADE** (with relevant details/ description of the aspects where alternative design is used, suitably indicated in the class certificate).

2.1.4 For designs developed using risk based design approaches as detailed in Section 3, the ships will be assigned an additional class notation RA. The class notation **RA** implies that the Ship Design is based completely on Risk based design considerations. However, if Risk based design approaches have been used for a particular aspect, the relevant details/ description will be suitably indicated in the class certificate.

2.1.5 For novel designs, additional notation **RA** is mandatory.

2.2 Definitions

2.2.1 *Accident Scenario*: A situation where one or more hazards are considered having materialized.

2.2.2 *Alternative Design*: A design different from a base design having equal to or stricter safety standard. (This design is composed of elements which deviate from the prescriptive requirement(s) of the Rules and/ or applicable statutory requirements, but are suitable to satisfy the intent of those requirements. The term includes a wide range of measures, including alternative shipboard structures and systems based on novel or unique designs, as well as traditional shipboard structures and systems that are installed in alternative arrangements or configurations.)

2.2.3 *Base Design*: A design which is in compliance with IRS rules and/or applicable statutory instruments.

2.2.4 *Design*: Specification of all relevant parameters for a ship as required for its successful construction and intended operation. This include the structure, machinery, outfitting, equipment, surveys/inspections and other items as may be required by the statutory and regulatory instruments.

2.2.5 *Design Basis*: A declaration of the expectations from the Alternative/Risk based design which includes but is not limited to the following:

- Description of the intended operations of the Ship
- Region where the Ship is to operate as intended
- Operational limits of the Ship
- Cargoes to be carried
- Any other relevant items

2.2.6 *Design Proposal*: Proposal for Alternative Design or Risk based Design which includes but is not limited to the following aspects

- Ship Arrangements
- Ship Scantlings
- Ship Machinery & Equipment (including maintenance schemes)
- Ship Survey & Inspection Schedule
- Provisions on Ship as in lieu of Statutory requirements

2.2.7 *Failure Mode*: A mechanism of failure due to a hazard. A hazard may materialize due to several failure modes singly or cumulatively. Likewise, there may be interlinking between several hazards and several failure modes

2.2.8 *Hazard*: A situation which has the potential to cause harm to the ship, personnel, environment and cargo.

2.2.9 *Novel Designs*: Designs which employ new concepts/technologies which are out of scope of the applicable rules. Novel Designs are to follow the Risk based design methodology.

2.2.10 *Risk based Design*: An alternative design with safety levels (which are no less stringent than the IRS rules and/or applicable statutory instruments) defined and determined by considering the safety risks.

2.2.11 *Safety Level*: A quantitative expression of the minimum required safety against identified hazards or failure modes.

2.2.12 *Submitter*: is an entity (owner, builder or designer) seeking approval of an alternative design/ risk based design from IRS/ the Administration, responsible for communicating with IRS/ the Administration for the submission and follow-up of the approval process.

2.3 Relevance to Statutory Instruments and Regulations of the Flag Administration

2.3.1 Notwithstanding the provisions of Section 3, an alternative design with reference to statutory and/or regulatory requirements is deemed to be in compliance with the present guidelines if it complies with the following documents as applicable and demonstrates the same to the satisfaction of IRS/ flag Administration :

1. MSC.1/Circ. 1455, as amended – Guidelines for approval of alternatives and equivalents
2. MSC.1/Circ. 1002, as amended – Guidelines for Alternative Design for Fire Safety
3. MSC.1/Circ. 1212, as amended – Guidelines for alternative design for Life Saving Appliances.
4. Relevant Notices/Circulars pertaining to alternative design issued by the flag Administration.

Section 3

Design Evaluation and Certification Process

3.1 Process Flow

3.1.1 The process flow for the design evaluation and certification is summarized in figure 3.1.1. The various stages in the figure are further described within the present section.

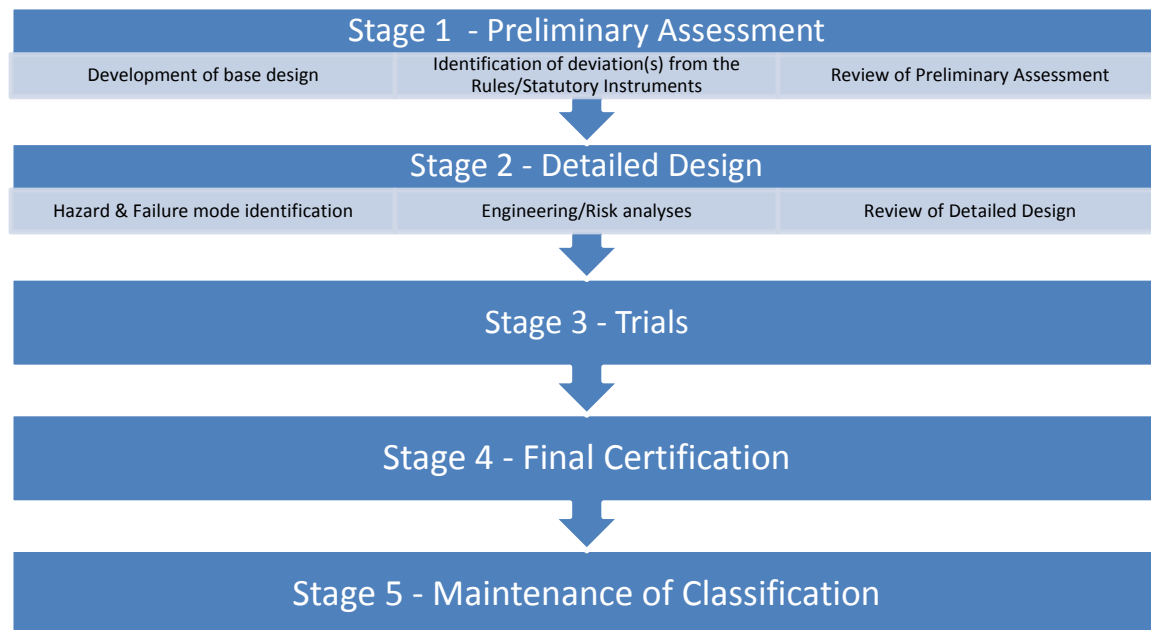


Figure 3.1.1. Process Flow for Design Evaluation and certification

3.2 Stage 1 – Preliminary Assessment

3.2.1 General

3.2.1.1 The submitter (owner, builder or designer) is to identify the major aspects pertaining to the design (e.g. structure, machinery, stability, fire safety etc.) which are envisaged to be proposed as alternatives to the rule requirements.

3.2.1.2 Based upon the aspects identified in 3.2.1.1, a team of experts (hereinafter referred to as the Design Team) is to be formed. The design team is a team of experts established by the submitter, which may include, relevant expert(s) having the necessary knowledge and experience. Such experts may typically include naval architects, marine engineers, structural engineers, mechanical engineers, fire experts, chemical engineers, electrical engineers, safety engineers, marine surveyors, ship operators, equipment manufacturers, human factor experts, etc.. It is recommended that expertise related to all the major aspects identified are represented adequately within the team, by means of domain knowledge and experience of the team personnel. It is preferable that a risk assessment expert be also included in the team. Risk based designs are to have risk assessment experts in the team.

3.2.1.3 The documentation (as applicable to alternative designs and risk based designs as shown in Table 3.2.1.3), is to be submitted to IRS for review at Stage 1.

| Table 3.2.1.3: Documentation requirements for Stage 1 | |
|---|--|
| Alternative Design | Risk based design |
| **Design basis (also refer 2.2.5) | **Design basis (also refer 2.2.5) |
| **Composition of the design team (also refer 3.2.1.2) | **Composition of the design team (also refer 3.2.1.2) |
| **Identification/development of base design (also refer 3.2.2) | ***Identification/development of base design also refer 3.2.2) |
| **Design proposal justifying the need for alternative design (also refer 2.2.6) | **Design proposal justifying the need for risk based design (also refer 2.2.6) |
| **Identification and listing of rules & regulations from which deviations are sought for the alternative design (also refer 3.2.3) | **Identification of rules & regulations from which deviations are sought for the risk based design (also refer 3.2.3) |
| **Acceptance criteria (also refer 3.2.4) | **Risk Acceptance criteria (also refer 3.2.4) |
| *** Drawings, Specifications, preliminary calculations and reports describing & justifying the need of the alternative design | *** Drawings, Specifications, preliminary calculations and reports describing & justifying the need of the risk based design |
| Hazard Identification | Hazard Identification |
| List of Codes & Standards proposed to be complied with, as an alternative to the rules | Risk assessment |
| Details of tests carried out /proposed | List of Codes & Standards proposed to be complied with for risk based features. |
| Surveys & Inspection Plans | Details of tests carried out /proposed |
| Maintenance Scheme | Maintenance Scheme |
| Any other documents which support the Alternative Design proposal | Surveys & Inspection Plans |
| - | Any other documents which support the Risk based Design proposal |
| <p>Note :</p> <p>** Mandatory Documentation to be submitted</p> <p>*** Although not mandatory, it is recommended to be submitted</p> <p>IRS may request additional documentation to be submitted if considered necessary</p> | |

3.2.1.4 It is recommended that the preliminary assessment stage be initiated by a kick-off meeting between the submitters and IRS (and the flag administration (if necessary)). The purpose of the kick-off meeting would be to facilitate the submitter to explain the design basis and proposal to IRS. The kick-off meeting may be followed by subsequent meetings in the other stages if deemed necessary to provide the submitter an opportunity to explain/elucidate the alternative/risk based design.

3.2.2 Development/Identification of Base design(s)

Alternative Design

3.2.2.1 A base design of the ship is to be identified/developed using the relevant IRS rules and/or relevant statutory instruments, pertinent to the scope of the alternative design. The base design may also be identified from an existing design which is compliant with IRS Rules and/or IMO Instruments.

Risk based Design

3.2.2.2 The base design development/identification is not mandatory for Risk Based Designs, although it is recommended that such a base design be developed.

3.2.3 Identification of deviations from IRS Rules/ statutory requirements

3.2.3.1 All deviations from the requirements of IRS Rules and/or Statutory requirements are to be identified, documented along with due rationale. This may be accomplished by providing reference to all the relevant clause(s) in the rules or alternatively all the clause text(s) may be reproduced from which the deviations have been sought.

3.2.4 Acceptance Criteria

Alternative Design

3.2.4.1 All failure modes addressed by the rule clauses which are deviated from are to be identified. Acceptance criteria are to be established by the submitter in consultation with IRS and/or relevant statutory bodies to address the identified failure modes and submitted to IRS for approval.

3.2.4.2 Acceptance criteria established are to demonstrate equivalency with the IRS Rules (i.e. provide an equal or stricter safety level)

3.2.4.3 Acceptance criteria pertaining to deviations from statutory requirements are additionally subject to approval from flag Administration.

Risk based Design

3.2.4.4 All failure modes addressed by the rule clauses which are deviated from are to be identified. Risk Acceptance criteria are to be established by the submitter to address the identified failure modes and submitted to IRS for approval. The Risk Acceptance Criteria are to consider and address the following:

- Probabilities and Consequences of failure of the Hull/Machinery
- Potential Loss of Life (PLL)
- Potential Environmental Impact
- Individual and/or Societal risks

3.2.4.5 Risk Acceptance criteria established are to demonstrate equivalency with the IRS Rules (i.e. provide an equal or stricter safety level)

3.2.4.6 Risk Acceptance criteria pertaining to deviations from statutory requirements are additionally subject to approval from flag Administration.

3.2.5 Review of Preliminary Assessment

3.2.5.1 The Stage 1 documentation submitted for preliminary assessment will be reviewed by IRS. Based upon the review, IRS may return or endorse the Design Proposal (with/without comments). If the Design Proposal is endorsed, the Submitter is to perform detailed analyses as described in Section 3.3 and submit the necessary documentation (also refer 3.3.3) to IRS for approval.

3.2.5.2 IRS review would provide comments (including, but not limited to) on the following aspects which have to be addressed by the Submitter in the final design:

- Design basis & scope (including the base design)
- Scope of the Hazard Identification exercise
- Composition of the Hazard Identification team
- Scenarios to be considered for engineering analysis or Risk assessment
- Recommended methods of Engineering analysis or Risk assessment
- Acceptance Criteria/ Risk Acceptance Criteria (as applicable) as described in 3.2.4

3.2.5.3 IRS may recommend a proposal of alternative design to be submitted as a risk based design if during the assessment it deems that the deviations with the Rules are substantial.

3.2.5.4 The Final approval of Alternative/Risk based Design is subject to fulfilment of the requirements of Section 3.3 and/or the approval by the flag Administration (if Statutory Instruments are also involved). The endorsement of the Design Proposal is not to be construed as a guarantee of approval of the final design.

3.3 Stage 2 – Detailed Design

3.3.1 Hazard & Failure mode Identification

3.3.1.1 A Hazard identification exercise is to be conducted considering the impact due to the Alternative design proposals introduced vis-a-vis the base design. The Hazard identification exercise is to be carried out by a qualified team of experts specializing in the major disciplines as identified in 3.2.1.1. Typically, the number of members of the HAZID team would be larger than that of the Design Team (refer 3.2.1.2). A facilitator should be appointed to co-ordinate the HAZID exercise. The Design Team should also be adequately represented at the HAZID exercise.

3.3.1.2 It is recommended that representatives of IRS pertinent to the approvals/certificates required and of the flag Administration are also participants or observers at such a Hazard identification exercise.

3.3.1.3 The Hazard identification team facilitator is to develop and finalize the scope of the exercise taking into account the major disciplines identified in Section 3.2.1, comments from IRS review in 3.2.5 and comments from the flag Administration where the statutory instruments are involved.

3.3.1.4 It is generally recommended that the Hazard identification exercise be carried out in sessions spanning over atleast two days (which may not be consecutive) so that the objective of the exercise is accomplished satisfactorily.

3.3.1.5 The hazards and their associated failure modes are to be identified using suitable techniques. The principles enumerated in ISO 31000 and IMO Circular MSC.MEPC.2/Circ.12/Rev.2 may be referred for further information.

3.3.1.6 The Hazards identified are to be ranked based upon their severity & likelihoods. Mitigation actions are to be identified to the extent readily possible. For the hazards for which mitigation actions cannot be readily identified, these need to be considered further for detailed risk analysis. It is recommended that the mitigation actions should be provided in terms of design options to the extent practicable. Prescription of operational measures in lieu of technical measures as an option for risk mitigation are to be avoided.

3.3.1.7 A final report detailing the results of the HAZID is to be developed. The report is to contain the following:

- Team Composition
- Changes (if any) in the design basis
- Hazards identified including those which were not identified as critical
- Failure modes triggered by the identified hazards
- List of mitigation measures proposed
- Areas and description of disagreement within the team
- List of Accident Scenarios/failure modes for which engineering analyses are to be performed to determine their criticality (also refer 3.3.2.1).

3.3.2 Engineering and/or Risk analysis

3.3.2.1 Accident scenarios are to be identified considering the design features and operational profile of the ship. Engineering analysis is to be carried out for each accident scenario. The following accident scenarios (including but not limited to) are to be considered as applicable:

- Structural failure (extreme loads, corrosion, fatigue etc.)
- Fire & Explosion
- Loss of Containment/Overpressure
- Loss of propulsion
- Flooding
- Loss of buoyancy/ loss of stability/ Capsizing
- Loss of station keeping
- Excessive ship motions
- Collision/Grounding
- Systems Failure
- Machinery/Equipment Failure
- Evacuation & Rescue
- Toxic Release

3.3.2.2 For engineering analyses performed for Alternative designs, compliance with the acceptance criteria (as agreed in 3.2.5) is to be demonstrated.

3.3.2.3 For Risk based designs, risk analyses (The principles enumerated in ISO 31000 and IMO Circular MSC.MEPC.2/Circ.12/Rev.2 may be referred for further guidance) are to be performed and the risk levels are to be evaluated. The risk level obtained by combining the consequences and the frequencies from the above steps are to be checked against the Risk Acceptance Criteria (as agreed in 3.2.5). The hazards/ accident scenarios for which the risk exceeds the tolerable limits are to be identified.

3.3.2.4 For Risk based designs, Risk Control Measures (RCM) in accordance with the IMO guidelines for Formal Safety Assessment (MSC.MEPC.2/Circ.12/Rev.2) are to be identified. Using the risk control measures, Risk Control Options are to be established.

3.3.2.5 The Risk Control Options selected are to be evaluated to demonstrate that the residual risk level is within the limits established within the Risk Acceptance Criteria.

3.3.2.6 A final report is to be developed enumerating the accident scenarios considered, results of the engineering analyses, results of the risk evaluation, risk control measures and options identified and the residual risk evaluation with the risk control measures, as applicable. Design measures are to take precedence over procedural measures for risk reduction.

3.3.2.7 The Survey/Inspection schedule (items & schedules) proposed for the Alternative/ Risk based design is also to be submitted. In addition, the submitter is to submit the maintenance philosophy for the equipment/ systems/ components proposed for the Alternative/ Risk based design.

3.3.2.8 IRS may require model tests to be conducted in addition to the engineering analyses, if considered necessary. IRS may conditionally accept model tests as an alternative to the engineering analyses if it is established that engineering analysis is not able to successfully capture the actual physical phenomena. For this purpose, a test plan is to be developed and submitted to IRS for approval which demonstrates that the accident scenarios/ failure modes identified in Section 3.3.1 are adequately simulated by the tests. IRS may require to inspect the test facility, test setup as well as witness the actual model testing, if considered necessary.

3.3.2.9 System integration is to ensure that individual sub-systems, equipment and components of each system and the system as a whole function appropriately, under normal and emergency conditions. System integration is to at least include the following considerations:

- Clear definition of individual sub-systems, equipment and components and their compatibility
- Assignment of overall responsibility for management and integration of the above
- Carried out in accordance with a detailed procedure which includes verification and validation.

3.3.3 Review of Detailed Design

3.3.3.1 The results of the Hazard Identification and the engineering/ risk analyses and/ or model tests (refer 3.3. and 3.3.2) are to be submitted to IRS for its review. The Final Drawings, Inspection & Survey Plans and Maintenance scope/ techniques/ schedules which incorporate the results of the engineering/risk analyses are to be submitted to IRS for approval.

3.3.3.2 IRS will review the detailed design documentation as described in 3.3.3.1. If satisfied that the design complies with the Acceptance/Risk Acceptance criteria, IRS will issue Design Approval in Principle (DAP). The DAP will clearly state the terms and conditions for which the Alternative/ Risk Based Design is verified and applicable.

3.4 Stage 3 – Tests and Trials

3.4.1 A plan for ship tests & trials is to be submitted to IRS for approval after the DAP is issued. The plan is to ensure that all items in scope of the Alternative Design/Risk Based Design are tested in alignment with the DAP. The plan is also to include verification of system integration aspects.

3.5 Stage 4 – Final Certification

3.5.1 Upon successful completion of surveys and trials, IRS will issue the Certificate of Classification and the class notation ADE/RA as applicable.

3.6 Stage 5 - Maintenance of Classification

3.6.1 The principles for maintenance of classification would be as indicated in the Part 1 of the *IRS Rules & Regulations for Construction & Classification of Steel Ships*. However, the inspection & survey schedule (see 3.3.3), scope and technique may vary depending on the extent of Alternative/ Risk based design features involved.

References

1. ISO 31000: Risk management – Principles and Guidelines
2. International Maritime Organization – Revised Guidelines for Formal Safety assessment (FSA) for use in the IMO Rule making process (MSC.MEPC.2/Circ.12/Rev.2)