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GUIDELINES ON
SHIP BUILDING AND REMEDIAL QUALITY STANDARD FOR MACHINERY PIPING SYSTEMS

JULY 2024

Guidelines

Shipbuilding and Remedial Quality Standard for Machinery Piping Systems

July 2024

Contents

Sections

Symbols and Abbreviations:

COW	: *combination welding process of gas metal arc and submerged arc welding for pipe during manufacturing*
DN	: *Nominal Diameter*
ID	: *Specified inside diameter of pipe*
NDT	: *Non-Destructive Testing*
OD	: *Specified outside diameter of pipe*
SAW	: *Submerged arc welding process for pipe during manufacture*
t	: *Specified wall thickness of pipe*
WPS	: *Welding Procedure Specification*

Section 1

Scope

1.1 General

1.1.1 This document provides guidance on shipbuilding quality standards for the machinery piping systems during ship new construction phase and the remedial standard where the quality standard is not met.

1.2 Application

1.2.1 In general, this document may be applied to the following:

- Machinery piping systems covered by the various Rules of IRS,

- piping systems serving ship propulsion, electricity generation and navigation safety and other machinery piping systems such as:

  - fuel oil filling, transferring, purifying, serving.
  - LNG dual fuels filling, transferring, preparing, serving
  - lubricating oil filling, transferring, purifying, serving.
  - compressed air for starting diesel engine, service, and instrument etc.
  - sea water cooling water, low/high temperature cooling fresh water, freshwater preheating/generating.
  - boiler feed water, steam generating, supply, heating coils, condensate, blow off, steam pressure releasing.
  - thermal oil
  - drain oil, oily bilge water collecting, treating, and discharging, sludge disposal and discharging.
  - flue gas
  - bilge and ballast water
  - firefighting e.g., fire-fighting water (main, emergency), fixed water-based local application, fixed gas (CO_2 or other), fixed pressure water-spraying and water-mist, High-expansion foam, fixed deck foam for oil tanker, fixed dry chemical powder, and water-spray (IGC/IGF code), sample extraction smoke detection
  - hydraulic fluid system, e.g., steering gear, valve remote control, windlass/winch, and hatch cover
  - air, vent, overflow and sounding pipes.
  - accommodation water, sewage/gray water, scupper, etc.
  - air conditioning and/or provision refrigerant conditioning,
  - exhaust gas abatement systems (EGCS, SCR, EGR) piping
  - gas detection system piping

- machinery piping systems constructed from carbon steel, carbon manganese steel, alloy steel, stainless steel, or other non-ferrous materials normally installed on board ships for services listed in *Pt.4, Ch.2, Table 1.2.1 of the Rules and Regulations for the Construction and Classification of Steel Ships* (hereinafter referred to as the Main Rules).

1.2.2 In general, this document does not apply to the new construction of

- Piping for structure purpose use,
- integrated or built-in pipes within the range of engine, skid, equipment or device
- piping systems for special purpose which might be needed to comply with special requirements, e.g., cargo piping, process piping, or submarine pipeline system, mud piping for dredging etc.,
- piping for nuclear power plant.

1.2.3 This document does not cover the quality requirements for product manufacture of piping equipment and piping components, regardless of whether they are made inside or outside of the Shipyard, examples being as follows. Evidence of acceptance should be provided by accompanying documentation from Surveyor at manufacturer, where required and verified by the Shipyard and provided to the Surveyor prior to commencement of fabrication:

- Pipes and flexible hose assemblies,
- Piping fittings, e.g., flanges, forged elbows, bellows, mechanical joints,
- Piping components, e.g., valves, gaskets etc.,
- Piping equipment, e.g., pumps, pressure vessels

1.3 In this document, both a "Standard" range and a "Limit" range are listed. The "Standard" range represents the target range expected to be met in regular work under normal circumstances. The "Limit" range represents the maximum allowable deviation from the "Standard" range. Work beyond the "Standard" range but within the "Limit" range is acceptable. In cases where no ‘limit’ value is specified, the value beyond the ‘standard’ range may be accepted subject to the consideration of IRS.

1.4 The document covers typical construction methods and gives guidance on quality standards for the most important aspects of such construction. The level of workmanship reflected herein will, in principle, be acceptable for machinery piping systems of conventional designs. A more stringent standard may however be required for critical and highly stressed sections of the piping systems. Pipes are subdivided into three classes as specified in *Pt.4, Ch.2, Table 1.2.1 of the Main Rules*.

1.5 Details relevant to piping systems or fabrication procedures not covered by this document will be approved by IRS on the basis of procedure qualifications and/or recognized standards.

1.6 For use of this document, fabrication fit-ups, deflections and similar quality attributes should be uniformly distributed about the nominal values. The Shipyard should take corrective action to improve work processes that produce measurements where a skew distribution is evident. Relying upon remedial steps that truncate a skewed distribution of the quality attribute is unacceptable.

Section 2

Terms and definitions

2.1 *Defect*: Imperfection of a size and/or population density greater than the acceptance criteria specified in this standard.

2.2 *Equipment connection:* An integral part of such equipment as pressure vessels, heat exchangers, and pumps, designed for attachment of pipe or piping components.

2.3 *Erection:* The complete installation of a piping system, including any field assembly, fabrication, testing, and inspection of the system.

2.4 *Fabrication*: The jointing of piping components into integral pieces ready for assembly. It includes bending, forming, threading, welding, or other operations upon these components, if not part of assembly. It may be done in a shop or in the field.

2.5 *Fixtures*: Fixtures include elements that transfer the load from the pipe or structural attachment to the supporting structure or equipment. They include hanging type fixtures, such as hanger rods, spring hangers, sway braces, counterweights, turnbuckles, struts, chains, guides, and anchors; and bearing type fixtures, such as saddles, bases, rollers, brackets, and sliding supports.

2.6 *Imperfection*: Discontinuity or irregularity in the product wall or on the product surface that is detectable by inspection methods outlined in this document.

2.7 *Manufacture*: The production process of piping components and piping equipment.

2.8 *Pipe*: A pressure-tight cylinder used to convey a fluid or to transmit a fluid pressure, ordinarily designated “pipe” in applicable material and dimensional specifications. Materials designated “tube” or “tubing” in the specifications are treated as pipe when intended for pressure service.
A pipe is a tube with a round cross section conforming to the dimensional requirements for nominal pipe size of a recognized standard.
A tube is a hollow product of round or any other cross section having a continuous periphery. Round tube size may be specified with respect to any two, but not all three, of the following: outside diameter, inside diameter and wall thickness.
The fundamental difference between pipe and tube is the dimensional standard to which each is manufactured.
According to the method of manufacture, type of pipe includes:

- seamless pipe: hot rolled (extruded, upset, forged, expanded)
- welded pipe: electric resistance-welded or induction welded pipe, furnace butt welded pipe, electric-fusion welded pipe, double submerged-arc welded pipe, spiral (helical seam) welded pipe, cold finished electric resistance or induction welded.
- cast pipe: normally centrifugally cast.

2.9 *Pipe classes:* For testing, the type of joint to be adopted, heat treatment and welding procedure, pipes are subdivided into three classes according to service, design pressure and temperature, as indicated in Pt.4, Ch.2, Table 1.2.1 of the Main Rules.

2.10 *Piping*: Assemblies of piping components used to convey, distribute, mix, separate, discharge, meter, control, or snub fluid flows. Piping also includes pipe-supporting elements, but does not include support structures, such as building frames, bents and foundations.

2.11 *Piping components*: Mechanical elements suitable for joining or assembly into pressure-tight fluid-containing piping systems. Components include pipe, tubing, fittings, flanges, gaskets, bolting, valves, air vent heads, bursting discs, flame screen, and devices such as expansion joints, flexible joints, pressure hoses assemblies, traps, filters, strainers, orifice plates, spool pieces, sight flow glasses, silencers, spark arresters, inline portions of instruments, and separators.

2.12 *Piping equipment*: Equipment or devices which are dedicatedly arranged to provide service for piping systems to perform limited functions which are an inseparable part of the piping system, such as independent oil tanks, pumps, air compressors, purifier, fans, heat exchangers or evaporators, pressure vessels, accumulators, dryers, filtration device with complex function, hydraulic power units, actuators, hydraulic motors, etc.
Equipment or engines that have separate complicated external functions and to which piping equipment provide service, such as diesels, turbines, boilers, or reduction gears, are excluded.

2.13 *Piping fittings*: Piping components that play the roles of connection, control, diversion, sealing, support, etc., and connect pipes into piping, such as flanges, bolts and nuts, joints of elbow, bends, branch tees, welding sleeve, bellows, reducers, caps, threads, mechanical joints. Pipes, strainers, valves, gaskets, hoses assemblies, or piping equipment are not piping fittings.

2.14 *Piping subassembly*: A portion of a piping system that consists of one or more piping components.

2.15 *Piping supporting elements*: Pipe-supporting elements consist of fixtures and structural attachments.

2.16 *Piping system:* An assembly of interconnected piping subject to the same set or sets of design conditions, normally consisting of piping and piping equipment, to serve a specific purpose.

2.17 *Restraint*: Any device that prevents, resists, or limits movement of a piping system.

2.18 *Soldering*: A metal joining process wherein coalescence is produced by heating to suitable temperature and by using a nonferrous alloy fusible at temperatures below 450°C and having a melting point below that of the base metals being joined. The filler metal is distributed between closely fitted surfaces of the joint by capillary action. In general, solders are lead-tin alloys and may contain antimony, bismuth, silver, and other elements.

2.19 *Standard Range and Limit Range*: “Acceptance Criteria” or “Tolerances” are defined by the values of a “Standard Range” and “Limit Range” according to each and relevant standards.

2.20 *Structural attachments*: Structural attachments include elements that are welded, bolted, or clamped to the pipe, such as clips, lugs, rings, clamps, clevises, straps, and skirts.

2.21 *Tack weld*: A weld made to hold parts of a weldment in proper alignment until the final welds are made.

2.22 *Recognized Fabrication Standard (RFS):* A RFS is a standard other than this document which provides guidance on quality standards for machinery piping systems during the ship's new construction phase and outlines remedial standards in cases where the quality standard is not met.

Section 3

General requirements for piping systems new construction

3.1 In general, the work should be carried out in accordance with IRS Rules. It may be noted that oversight and management of compliance with the Rules falls within the purview and responsibility of the Shipyards.

3.2 Welding operations is to be carried out by qualified operators in accordance with WPS approved by IRS.

3.3 Welding of piping is to be carried out by qualified welders, according to approved and qualified welding procedures and with welding consumables approved by IRS, (see Section 4). Welding operations are to be carried out under proper supervision by the Shipyard. The welding conditions are to be monitored in accordance with IRS Rules or other recognized standards accepted by IRS.

Section 4

Qualification of Personnel and Procedures

4.1 Qualification of Procedures

4.1.1 Welding procedures for metallic pipe should be qualified in accordance with relevant requirements in Pt.4, Ch.10 of the Main Rules or other recognized standards accepted by IRS.

4.1.2 Bonding procedures or fusion procedures for nonmetallic pipe should be qualified in accordance with relevant requirements in Pt.4, Ch.2, Sec.5 of the Main Rules or other recognized standards accepted by IRS.

4.1.3 Plastic coating or lining procedure for steel-plastic composite pipe should be qualified in accordance recognized standards accepted by IRS.

4.2 Qualification of Personnel

4.2.1 Welders should be qualified in accordance with the procedures approved by IRS or to a recognized national or international standard. Recognition of other standards is subject to submission for evaluation. Records of welders' qualifications certificate is to be maintained by the Shipyard.

4.2.2 The welding operator responsible for setting up and/or adjustment of fully mechanized and automatic equipment, such as MAG welding with auto-carriage, etc., is to be qualified whether he operates the equipment or not. However, a welding operator, who solely operates the equipment without responsibility for setting up and/or adjustment, does not need qualification provided that he has experience of the specific welding work concerned and the production welds made by the operators are of the required quality.

4.2.3 Bonder and bonding operator of non-metallic pipe joint should be qualified and pass a performance qualification test in accordance with recognized standards accepted by IRS.

4.3 Qualification of NDT operators

4.3.1 For the requirements for qualification of personnel performing non-destructive examination, for the purpose of assessing the quality of welds in connection with piping fabrication covered by this document, refer to *Classification Note on Requirements for NDT Suppliers*. Records of operators and their current certificates should be maintained by the Shipyard and made available to the Surveyor for inspection.

4.4 Requirements for Quality Management Systems of Shipyard

4.4.1 An independent quality control system, with different classified levels of inspection and application for inspection, personnel qualification, and instruments calibration etc., should be developed by Shipyard or parties who are responsible for piping fabrication.

4.5 Requirements for procedure documents

4.5.1 Work for welding, bonding, NDT, and installation is to comply with the procedures approved or accepted by IRS.

Section 5

Materials

5.1 Material for piping systems

5.1.1 Material, dimension, type, model and capacity of piping components and piping equipment installed onboard, should comply with the design standard, and should be suitable for the marine environment and its intended specified application consistent with ship design where it to be used, and should be approved and provided with relevant certificates (refer Pt.2, Ch.6 of the Main Rules) required by IRS.

5.1.2 Requirements for the selection of applicable metallic materials to be used for various pipes, valves and fittings are specified in Pt.4, Ch.2 of the Main Rules.

5.1.3 For the application of materials for piping systems in corrosive media, each case should be agreed with IRS.

5.1.4 All materials used, including welding consumable, are to be manufactured at a works approved by IRS for the type and grade supplied, unless otherwise agreed on as a case-by-case evaluation.

5.2 Surface Conditions

5.2.1 All pipes, piping fittings, plastic liners, valves, piping equipment should maintain good surface condition and be free from defects after manufacture, transportation, delivery, storage, before fabrication and after erection on board.

5.2.2 Any degradation use of pipe with defect should be assessed and accepted by IRS, ship owner and any stakeholder.

5.2.3 Some common pipe surface imperfections and defects are listed in Table 5.2.3

Table 5.2.3 : List of possible pipe surface imperfections and defects	
Steel Pipe in Locations other than the Weld	arc burns, blister, crack, dent, eccentricity, gouge, hard spot, inclusion, lamination, lap, pit, plug scores, ring mark/pattern, roll mark, scab, scale, seam, sliver, slug, stretch mill indentation, stretch mill overfill, tear, upset underfill, upset wrinkles,
Electric Resistance Welds	black spot, contact marks, edge damage, edge misalignment, excessive trim, hook cracks upturned fiber imperfections, inadequate flash trim, inadequate normalization of weld seam, incomplete fusion, open seam lack of fusion, penetrator, pinhole, stitching, weld area crack
Double Submerged Arc Welds	excessive reinforcement, excessive overfill, incomplete fusion, incomplete penetration/lack of penetration, misalignment of weld beads/out-of-line weld beads/off seam, offset of plate edges, pinhole, porosity, slag inclusions, undercut, weld area crack,
Threads	black-crested thread, broken thread, burr, chatter, cut, ding, false starting thread/double starting thread, featheredge, fin, galling, handling damage, improper thread form, improper thread height, interrupted starting thread, knife edge/razor edge, non-full-crested thread, pitted threads, shaved thread/thin thread, shoulder, slivers under coupling, step, tool mark, torn thread/tears, wavy thread/drunken thread, wicker/whisker,

5.2.4 Pipes should have smooth surfaces inside and outside; pipe ends should be perpendicular to the axis and have no burr. Crack, lap, laminations, scab, rolling wrinkle, burr, arc burns, and serious rust are not allowed on the inner and outer surfaces of the steel pipes/tubes. These defects should be completely removed by mechanical means and ground smoothly to the pipe surface, and the actual wall thickness of the remedied part should not be less than the minimum allowable value of the wall thickness after remedial work.

5.2.5 Seamless steel pipes and body of welded steel pipes

5.2.5.1 Depth of piping plug

.1 The depth of plug on pipe outside and inside surface is to be according to Table 5.2.5.1.1.

Table 5.2.5.1.1 : Maximum allowable depth of plug on pipe outside and inside surface		
Pipe Type	**Material**	**Depth of plug on pipe surface**
Cold Drawn or Cold Rolled Pipes	Carbon, Carbon Manganese	Max. 4% of nominal wall thickness, max. 0.20[mm]
	Stainless	Max. 4% of nominal wall thickness, max. 0.30[mm]
Hot Rolled, Extruded, or Expanded Pipes	Carbon, Carbon Manganese	Max. 5% of nominal wall thickness, max. 0.4[mm]
	Stainless	Max. 5% of nominal wall thickness, max. 0.50[mm]

5.2.5.2 Dent

.1 The dent length in any direction should be ≤ 0.5 OD, and the depth, measured as the gap between the extreme point of the dent and the prolongation of the normal contour of the pipe, should not exceed the following:

a) Max. 10% of pipe's thickness for cold formed dents with sharp-bottom gouges,
b) Max. 20% of pipe's thickness for other dents.

.2 Dents that exceed the specified limits should be considered as defects and should be treated accordingly.

5.3 Remedial actions for defects

5.3.1 Base metal

.1 Generally, base metal of class I and II should not be allowed to be remedied by welding, weld bead remedial for welded pipes with OD ≤ 219.1[mm] is not permissible.

5.3.2 Bead

.1 Weld bead might be remedied by weld for pipes with OD > 219.1 [mm].

.2 Before remedy welding,

a) the remedy spot should be treated to make it meet the remedy WPS requirement approved by IRS.
b) The single remedy welding length to be not less than 50 [mm], but not longer than 150 [mm] for electric resistance-welded pipe.
c) Remedy welding should not exceed 3 places per steel pipe.
d) No remedy is allowed within 200 [mm] from pipe end.
e) Bead to be ground smoothly to base metal after remedy, and NDT and hydraulic test to be repeated.

5.3.3 Treatment

5.3.3.1 Surface Imperfections

.1 Surface imperfections not classified as defects may remain in the pipe without repair or may be dressed-out by grinding.

5.3.3.2 Dressable Surface defects

.1 All dressable surface defects should be dressed-out by grinding.

.2 Grinding should be carried out in such a way that the dressed area blends in smoothly with the contour of the pipe.

.3 Complete removal of defects should be verified by local visual inspection, aided, where necessary, by suitable non-destructive examination methods. To be acceptable, the wall thickness in the ground area should be in accordance with wall thickness deviation; however, the minus tolerances for diameter and out-of-roundness will not apply in the ground area.

5.3.3.3 Non-dressable Surface Defects

5.3.3.3.1 Pipe that contains non-dressable surface defects should be given one or more of the following dispositions:

.1 Weld defects in SAW and COW pipe should be repaired by welding in accordance with 5.3.3.4.

.2 The sections of pipe containing the surface defects should be cut off, within the limits on length;

.3 The entire pipe length should be rejected.

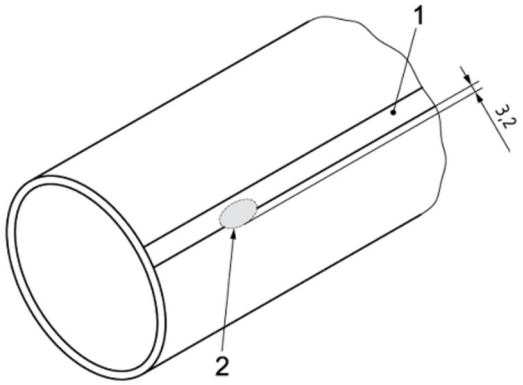
5.3.3.4 Repair of Defects by Welding

.1 Repair of the pipe body by welding is not permissible for class I and II pipes.

.2 Except as not allowed by 5.3.3.4.1, repair by welding should be confined to the weld of SAW and COW pipe. The defect should be completely removed, and the resulting cavity should be thoroughly cleaned. NDT may be carried out If deemed necessary. For class I and II pipe, the rim of the resulting cavity should not extend into the parent metal by more than 3.2 [mm], as measured along the pipe surface perpendicular to the weld (see Fig. 5.3.3.4.2). Unless otherwise agreed, repairs to welds in cold-expanded class I and II pipe should have been performed prior to cold expansion. Seam welds made without filler metal are not to be repaired by welding.

.3 The total length of repaired zones on each pipe weld should be ≤ 5 % of the total weld length for SAW and COW weld seams. For rolled-plate pipe, the total length of the repaired zone should not exceed 100 [mm] and should not be within 100 [mm] of the cross-weld joint between the end pipe weld and the helical or longitudinal seam weld.

.4 Weld defects separated by less than 100 [mm] should be repaired as a continuous single weld repair. Each single repair should be carried out over a length of at least 50 [mm].



1 weld reinforcement
2 rim of resultant cavity

Fig. 5.3.3.4.2 : Resultant Cavity of Weld Repair (for class I and II)

.5 Weld repairs should be performed using a welding procedure that is qualified in accordance with a recognized standard and approved by IRS.

.6 After weld repair, the total area of the repair should be ultrasonically or radiographically inspected or subjected to at least the same NDT as specified for the original weld. Before expansion or hydrostatic testing, the type of ultrasonic testing (UT) may be at the option of the pipe manufacturer; however, after expansion or hydrostatically testing, inspection should be done by manual UT. It would also be acceptable to carry out combined automatic and manual UT after expansion or hydrostatically testing.

.7 For seamless pipe (class III only), prior to weld repair, magnetic particle testing (MT) or penetrant testing (PT) inspection should be performed to ensure complete removal of defect.

.8 A pipe that has been repair welded should be hydrostatically tested after repair welding.

Section 6

Workshop Fabrication

6.1 General

6.1.1 This section provides guidance for the workshop fabrication process, covering cutting, bending, edge preparation, and assembly. From selecting appropriate cutting methods to ensuring precise dimensions and surface quality, each step is detailed. With a focus on maintaining high standards and quality, this section serves as a comprehensive guide for manufacturers during the workshop fabrication.

6.2 Cutting

6.2.1 Permitted cutting method for different material

.1 Non-ferrous metal pipe, galvanized welded pipe and OD ≤ 32 [mm] steel carbon pipe can use mechanical or plasma cutting, OD > 32 [mm] steel carbon pipe may use gas cutting; stainless steel pipe is recommended to use mechanical or low temperature cutting.

6.2.2 Roughness of cut edge

Table 6.2.2 : Roughness of cut edge	
Pipe class	**Roughness**
I, II	200 [μm]
III	300 [μm]

6.2.3 Cut end perpendicularity

Table 6.2.3 : Cut end perpendicularity	
DN	**Perpendicularity**
≤100	≤1°
100~200	≤2°
>200	≤3°

6.2.4 Length tolerance

Table 6.2.4 : Length tolerance	
DN	**Tolerance (per meter)**
≤50	±1 [mm]
65~125	±2 [mm]
>125	±3 [mm]

6.3 Bending

6.3.1 Longitudinal weld arrangement

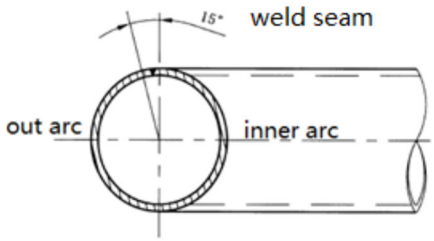


Fig. 6.3.1 : Longitudinal weld arrangement

6.3.2 Heat temperature range and post heat treatment

6.3.2.1 Heating is not to impair the specified properties of the materials, which might be verified, if necessary, when hot forming is subsequent to heat treatment. The manufacturer should demonstrate to IRS that forming process and operating conditions are such as not to impair the materials properties. The forming procedure, together with any subsequent heat treatment, should be subject to qualification test on sample reproducing all condition intended for production heat forming. The qualification tests should include, as a minimum, a set of three Charpy V-notch impact tests and one tensile test. The results should be in accordance with the base material specification.

6.3.2.2 Hot bending heating temperature referred to Table 6.3.2.2.

Table 6.3.2.2 : Hot bending heating temperature

Material	**Starting temperature (℃)**	**Ending temperature (℃)**
Carbon, C-Mn	900~1050	700
Copper	850~860	300
Brass	600~700	400
Molybdenum/molybdenum-chrome steel	900~1000	750
Duplex metal*	1200	900
Austenitic stainless	950~1100	850
Note: * As per steel manufacturer's recommendations.		

6.3.2.3 When steel hot forming is carried out outside the above temperature range, a subsequent new heat treatment in accordance with Table 6.3.2.3 below is generally required for all grades.

Table 6.3.2.3 : Heat treatment and Temperature range for type of steel	
Type of steel	**Heat treatment and temperature (℃)**
C and C-Mn	Normalizing 880 to 940
0.3 Mo	Normalizing 900 to 940
1 Cr – 0.5 Mo	Normalizing 900 to 960 Tempering 640 to 720
2.25 Cr – 1 Mo	Normalizing 900 to 960 Tempering 650 to 780
0.5 Cr – 0.5 Mo – 0.25 V	Normalizing 930 to 980 Tempering 670 to 720

6.3.2.4 After cold bending with bending radius less than 4 times OD, a stress relieving heat treatment in accordance with Table 6.3.2.4 below is required for all grades other than carbon and carbon-manganese steels with R_m 320, 360 and 410, duplex steels and austenitic stainless steels.

Table 6.3.2.4 : Stress relieving heat treatment for all grades other than carbon and carbon-manganese steels with R_m 320, 360 and 410, duplex steels and austenitic stainless steels		
Material	**Thickness of thicker part [mm]**	**Annealing process (temperature / time/cooling)**
C and C-Mn	≥15[1&3]	600~650 ， 1h per each 25 [mm] of thickness, air cooling
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
Copper, copper alloy	any	500 to 700

Note:
1. When steels with specified Charpy V notch impact properties at low temperature are used, the thickness above which post weld heat treatment should 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 design temperature 450°C.
3. For C and C-Mn steels, stress-relieving heat treatment may be omitted up to 30 [mm] thickness by special agreement with IRS.

6.3.3 Minimum thickness recommendation

Table 6.3.3 : Minimum thickness recommendation	
Bend radius	**Recommended minimum thickness**
≥6 times OD	$1.06 \times t_m$
5 times OD	$1.08 \times t_m$
4 times OD	$1.14 \times t_m$
3 times OD	$1.25 \times t_m$

Note:
t_m is required minimum wall thickness in accordance with calculation formula of design requirement.

6.3.4 Bending radius

Table 6.3.4 : Bending radius			
Bending radius (C, C-Mn)	**standard**	**limit**	**< 2 times OD**
	≥ 3 times OD	2~3 times OD	Elbow to be used.

6.3.5 Bending surface quality

6.3.5.1 There should be no cracks, scab, over heated, lap, and lamination at the bending section. The above imperfections should be completely removed, and the remaining wall thickness should be still within permitted tolerance. There should be no obvious scratched groove or collision dents in the pipe wall. Grooves with depth less than 10% wall thickness, and dents with depth less than 5% OD are acceptable.

6.3.6 Wall thickness thinning rate

Table 6.3.6 : Wall thickness thinning rate						
Item				**Standard %**	**Limit %**	**Remark**
$F= [(t_a-t_b)/t_a]x100$ F-Wall thickness thinning rate (%) t_a-wall thickness before bending t_b -minimum wall thickness after bending	steel pipe	$R_2 \leq 2DN$	C.B.	—	—	R_2 – bending radial DN – nominal diameter C.B. - cold bending H.B. - hot bending
			H.B.		20	
		$2DN < R_2 \leq 3DN$	C.B.		25	
			H.B.		13	
		$3DN < R_2 \leq 4DN$	C.B.		20	
			H.B.		12	
		$R_2 > 4DN$	C.B.		15	
			H.B.		12	
	copper pipe	$R_2 \leq 2DN$	C.B.		—	
			H.B.		20	
		$2DN < R_2 \leq 3DN$	C.B.		30	
			H.B.		15	
		$3DN < R_2 \leq 4DN$	C.B.		25	
			H.B.		10	
		$R_2 > 4DN$	C.B.		20	
			H.B.		10	
	aluminium brass	$R_2 \leq 2DN$	C.B.		25	
		$2DN < R_2 \leq 3DN$			25	
		$3DN < R_2 \leq 4DN$			20	
		$R_2 > 4DN$			15	

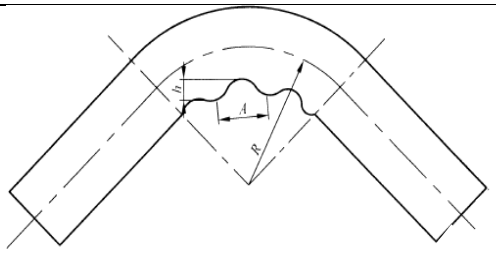
6.3.7 Roundness

Table 6.3.7 : Roundness						
Item				**Standard %**	**Limit %**	**Remark**
E =[(D_{max} - D_{min})/D_w]x100 E-roundness (%) D_{max} – max OD on cross section after bending D_{min} – minimum OD on cross section after bending D_w – actual wall thickness before bending	steel pipe, copper pipe	$R_2 \leq 2DN$	C.B.	—	—	R_2 – bending radial DN – nominal diameter C.B. - cold bending H.B. - hot bending
			H.B.		10	
		$2DN < R_2 \leq 3DN$	C.B.		10	
			H.B.		8	
		$3DN < R_2 \leq 4DN$	C.B.		10	
			H.B.		8	
		$R_2 > 4DN$	C.B.		10	
			H.B.		5	
	aluminium brass	$R_2 \leq 2DN$	C.B.		15	
		$2DN < R_2 \leq 3DN$			10	
		$3DN < R_2 \leq 4DN$			10	
		$R_2 > 4DN$			8	

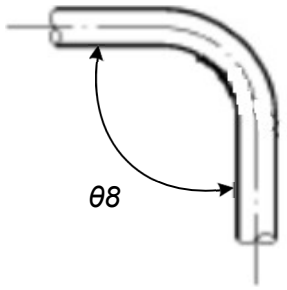
6.3.8 Reduction in cross-sectional area

Table 6.3.8 : Reduction in cross-sectional area				
Item		**Standard %**	**Limit %**	**Remark**
R =[1-[(A+B)/2D_W]]x100 R - reduction rate of cross-sectional area (%) A - max cross-sectional area after bending B - min cross-sectional area after bending D_w - actual cross-sectional	$R_2 \leq 2DN$	—	6	R_2 – bending radial DN – nominal diameter C.B. - cold bending H.B. - hot bending
	$2DN < R_2 \leq 3DN$		5	
	$3DN < R_2 \leq 4DN$		4	
	$R_2 > 4DN$		3	

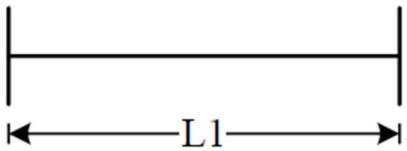
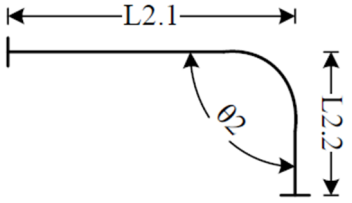
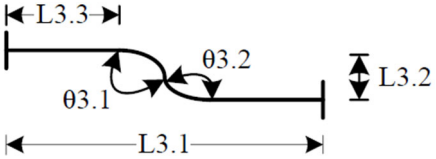
6.3.9 Creasing

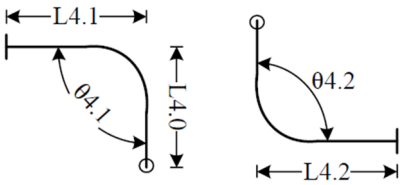
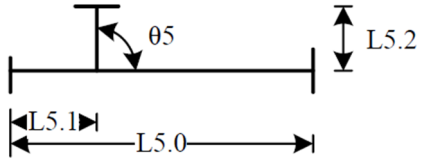
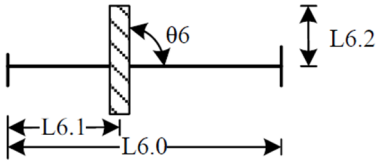
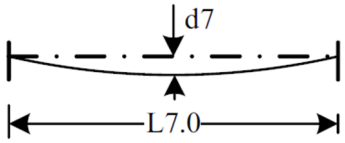
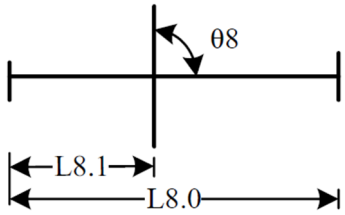
Table 6.3.9 : Creasing			
Item	**Standard [mm]**	**Limit [mm]**	**Remark**
 Creasing	h ≤ D_W×2% A/h >12	—	D_w - actual wall thickness before bending creasing length h - creasing height

6.3.10 Angle

Table 6.3.10 : Bending angle				
Item		**Standard**	**Limit**	**Remark**
bending angle 	Δθ8	±1°	—	

6.3.11 Shape and position deviation

Table 6.3.11 : Shape and position deviation				
Item		**Standard**	**Limit**	**Remark**
Straight pipe  L1 – Straight pipe length	ΔL1	±3[mm]	±6[mm]	—
Bent pipe  L2.1 – first bent pipe length L2.2 – second bent pipe length θ2 – bend angle	ΔL2.1	±3[mm]	±6[mm]	—
	ΔL2.2	±3[mm]		
	Δθ2	±1°	—	
Double bend pipe  L3.1 - total length L3.2 - space L3.3 - original bend pipe length θ3.1, θ3.2 - bend angles	ΔL3.1	±3[mm]	±6[mm]	—
	ΔL3.2	±3[mm]	±66[mm]	
	ΔL3.3	±3[mm]	±6[mm]	
	|θ3.1-θ3.2|	±1°	-	

Tridimensional bend pipe  L4.0 - bend height L4.1, L4.2 - straight section length θ4.1, θ4.2 - bend angle		ΔL4.0	±3[mm]	±6[mm]	—
		ΔL4.1	±3[mm]	±6[mm]	
		ΔL4.2	±3[mm]	±6[mm]	
		Δθ4.1 Δθ4.2	±0.5°	±1°	
Branch pipe  L5.0 - main pipe length L5.1 - space between branch and main pipe end L5.2 - branch pipe length θ5 - angle between main and branch pipe		ΔL5.0 ΔL5.1 ΔL5.2	±3[mm]	±6[mm]	—
		Δθ5	±0.5°	±1°	
Penetrating pipe  L6.0—penetrating pipe length L6.1—length between pipe flange and web θ6—angle between pipe and web		ΔL6.0 ΔL6.1	±3[mm]	±6[mm]	—
		Δθ6	±0.5°	±1°	
Pipe straightness deflection  L7.0—straight pipe length	DN≥40	d7	≤1.5*L7.0/1000	-	a)
Cross pipe  L8.0—cross pipe length L8.1—length between pipe flange and cross pipe θ8—angle between pipes		ΔL8.0 ΔL8.1	±3[mm]	±6[mm]	b)
		Δθ8	±0.5°	±1°	

6.4 Edge preparation and assembly

Edge preparation should be in accordance with approved drawings and should conform to the approved WPS. The preparation of the edges should be preferably carried out by mechanical means. When flame cutting is used, care should be taken to remove the oxide scales, and HAZ (heat affected zone) if necessary.

6.4.1 Cleaning

6.4.1.1 Oil, paint, fouling and rust should be removed on edge and base metal within following range in Table 6.4.1.1.

Table 6.4.1.1 : Method and cleaning range to remove oil, paint, fouling and rust

Material	Cleaning range	Cleaned object	Cleaning method
C, C-Mn, alloy, stainless steel	>10[mm]	Oil, paint, rust, burr	Manual, mechanical
Al alloy	>50[mm]	Oil, oxidation film	Organic solvents remove oil Chemical or mechanical method remove oxidation film
Copper and its alloy	>20[mm]		
Ti alloy, Ni alloy	>50[mm]		

6.4.2 Misalignment tolerance

Table 6.4.2 : Misalignment tolerance

Material	ID	Wall thickness	Misalignment tolerance
C, C-Mn	any	any	with permanently fitted backing ring: 0.5 [mm]
	<150[mm]	Up to 6[mm]	without permanently fitted backing ring: 1 [mm] or t/4, whichever is less
C, C-Mn	<300[mm]	6~9.5[mm]	without permanently fitted backing ring: 1.5 [mm]
C, C-Mn	≥300[mm]	>9.5[mm]	without permanently fitted backing ring: 2.0 [mm]
Stainless steel	any	any	≤0.5[mm]
Al alloy	any	≤5[mm]	≤0.5[mm]
	any	>5[mm]	10% of t, max. 2[mm]
Cu, Ti, Ni alloy	any	any	10% of t, max. 1[mm]
Note: For Class III piping systems, the requirements for alignment tolerances may be waived at the discretion of IRS.			

6.4.3 Distance between welds

Table 6.4.3 : Distance between welds		
Item	**DN**	**Distance between welds**
circumferential weld seam	<150[mm]	≥OD or 100[mm], whichever is greater
	≥150[mm]	≥OD
	stiffening ring and pipe	≥50[mm]
	away from bend starting point	≥OD or 100[mm], which is bigger
	away from pipe support	≥50[mm] ≥5 times OD, or 100[mm], which is bigger if post weld heat treatment is required.
	away from branch weld	≥50[mm]
Longitudinal seam	adjacent pipe section	>3 times wall thickness or 100[mm], which is bigger
	In same pipe section	≥200[mm]
	stiffening ring and pipe	≥100[mm]
	away from branch weld	≥50[mm]

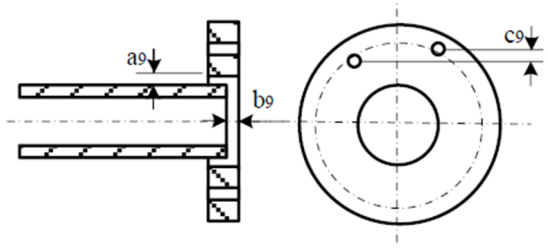
6.4.4 Tack weld

6.4.4.1 Tack welds should be made with an electrode suitable for the base metal. Tack welds which form part of the finished weld should be made by qualified welders, using approved procedures, otherwise tack welds should be completely removed before full welding.

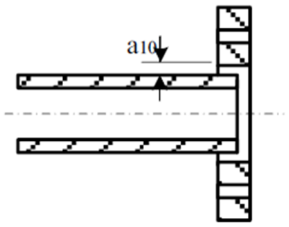
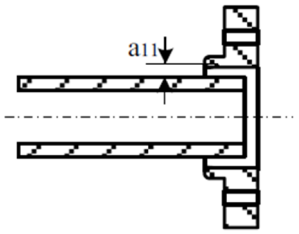
6.4.4.2 When welding materials require preheating, the same preheating should be applied during tack welding in accordance with Table 6.4.4.2.

Table 6.4.4.2 : Preheating applied during tack welding			
Item	**DN**	**Standard**	**Limit**
quantity	15~32		2
	40~100		3
	125~250		4
	≥300		8
Inter-angle	15~32	180°	
	40~100	120°	
	125~250	90°	
	≥300	45°	
Weld length	15~32	10[mm]	
	40~100	10[mm]	
	125~250	10[mm]	
	≥300	10[mm]	

6.4.5 Typical edge preparations

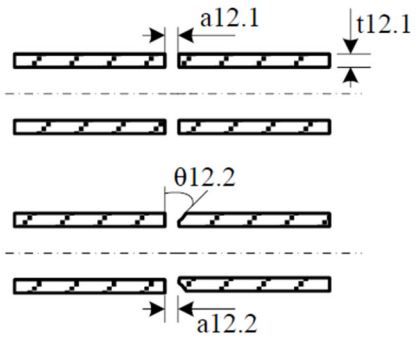
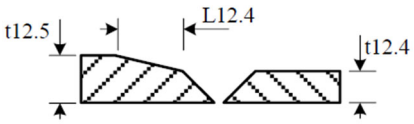
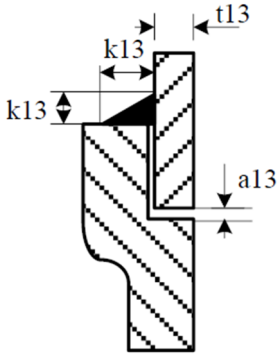
Table 6.4.5 : Typical edge preparations				
Steel pipe and flange		**Standard**	**Limit**	**Remark**
 a9—radial clearance b9—end space c9—bolt hole misalignment	b9	K ~ K+1	-	K- fillet weld leg height
	a9	≤ 3.0[mm]		
	c9	≤ 1.0[mm]		

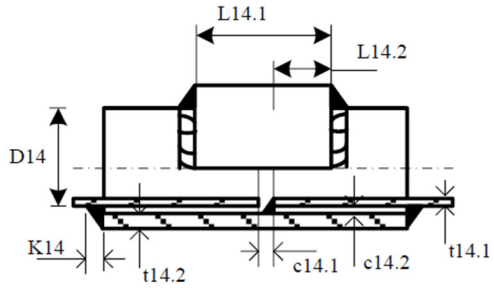
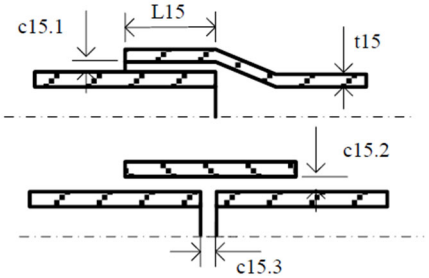
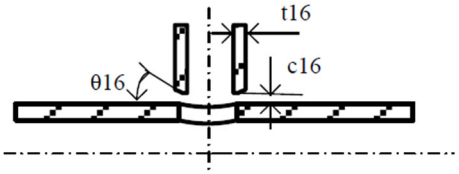
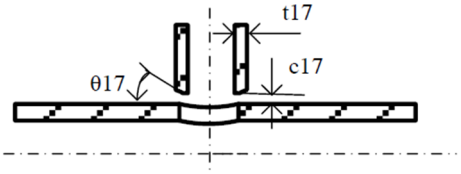
6.4.6 Copper pipe and flange

Table 6.4.6 : Copper pipe and flange				
Item		**Standard**	**Limit**	**Remark**
 a10 - clearance	a10	≤ 0.2		
 a11- clearance	a11	≤ 0.2[mm]		

6.4.7 Pipe segment

Table 6.4.7 : Pipe segment

Item			Standard	Limit	Remark
 a12.1, a12.2 - space between pipes θ12.2 - groove angle	t12 ≤ 3	a12.1, a12.2	1.0 ~ 1.5[mm]	≤ 3.0	
	3 < t12 ≤ 6		1.5 ~ 2.0[mm]		
		θ12.2	> 30°	≤ 40°	
	t12 > 6	a12.1, a12.2	2.0 ~ 3.0[mm]	≤ 4.0	
		θ12.2	≥ 50°	≤ 60°	
t12 – pipe wall thickness  t12.4, t12.5-pipe wall thickness L12.4-beveling length.	Different wall thickness	L12.4	(3~4) ×(t12.5-t12.4)	As per rule	
 k13-fillet weld leg height t13-pipe wall thickness a13-end gap		k13	> 1.25×t13		
		a13	> 1.5[mm]		

Sleeve weld  t14.1-pipe wall thickness t14.2-sleeve wall thickness c14.1-end gap c14.2-clearance between pipe and sleeve L14.1-sleeve length L14.2-inserted length in sleeve D14-OD of pipe K14-fillet weld leg height		L14.1	≥ D14		
		L14.2	≤ L14.1/2	≥ 15	
		t14.2	≥ 1.25 ×t14.1		
		c14.1		≥ 1.5	
		c14.2	≤ 1.5[mm]	≤ 2.0	
		K14	≥ t14.1		
Sleeve brazing/soldering  c15.1, c15.2-clearance between pipe and sleeve c15.3-space between both pipe end L15-insert length t15-pipe wall thickness		c15.1, c15.2	≤ 0.2[mm]		
		c15.3	≤ 1.0[mm]		
		L15	≥ 5×t15		
Branch joint-steel pipe welding  c16- clearance between main and branch pipe θ16- groove angle t16- branch wall thickness d16- coaxiality deviation between branch/hole	t16 ≤ 4	c16	1.0~2.0 [mm]	≤ 3.0	
		d16	1.0 [mm]	2	
	t16 > 4	c16	2.0~3.0 [mm]	≤ 4.0	
		θ16	> 45°	≤ 50°	
		d16	1.0 [mm]	2	
Branch joint-brazing/soldering  c17—clearance between main and branch pipe θ17—groove angle t17—branch wall thickness d17—coaxiality deviation between branch/hole	t17 ≤ 3	c17	≤ 1.0 [mm]	≤ 2.0	
	3 < t17 ≤ 6		≤ 1.5 [mm]	≤ 3.0	
		θ17	> 45°	≤ 60°	

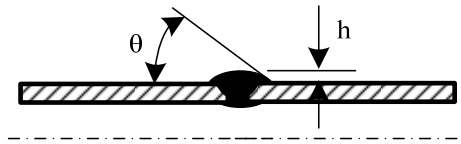
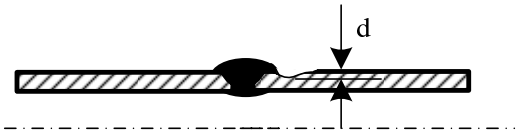
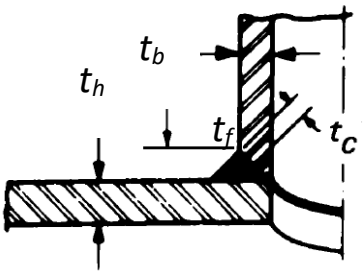
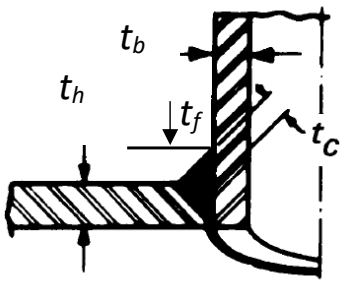
6.5 Preheating and Post heat treatment of welding

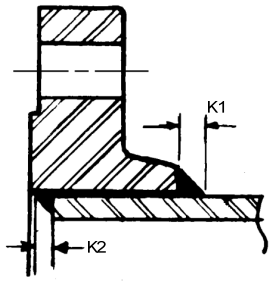
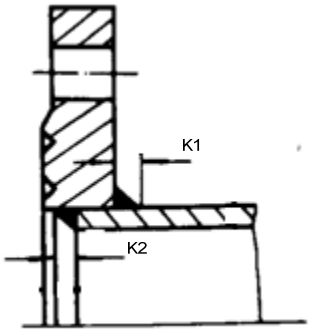
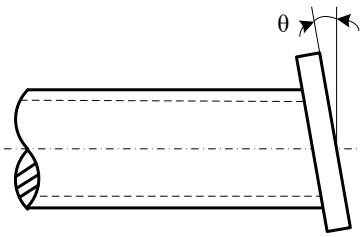
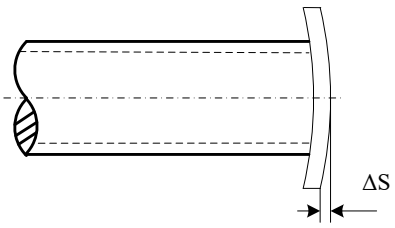
6.5.1 Preheating and post heat treatment of the different types of steels will be dependent upon their thickness and chemical composition. For details, refer to Pt.4, Ch.10, Sec.3 of the Main Rules.

6.6 Typical weld profile and Weld surface quality

6.6.1 There should be no cracks, flash, overlap, porosities, sag, incomplete penetration, or fusion, burn-through on the weld surface.

Table 6.6 : Typical weld profile and Weld surface quality

Detail		Standard	Limit	Remarks
Butt weld reinforcement 	θ	≤ 50°	≤ 70°	
	h	≤ 2[mm]	≤ 4[mm]	h > 0[mm] always
Butt weld undercut 	d	Class I: 0; Class II, III: ≤ 0.4[mm]	Class I: 0; Class II, III: ≤ 0.6[mm]	Single undercut continuous length <100[mm], total undercut length <10% total weld length
Fillet weld leg length/throat   Tc—crotch thickness of branch connections measured at the center of the crotch	tc	≥ 0.7tb	≥ 0.63tb	
	tf	≥ tb	≥ 0.9tb	

 t1— pipe thickness t2— hub thickness		K1	The lesser of 1.4t1 or t2		
		K2	The lesser of t1 or 6[mm]		
		K1	1.5t	6[mm]	
		K2	t	5[mm]	
	DN<150	30’		-	
	DN≥150	20’		-	
	DN<200	≤0.5[mm]		<1.0[mm]	
	200≤DN<450	≤1.0[mm]		<2.0[mm]	
	DN≥450	≤1.0[mm]		<2.5[mm]	

6.7 NDT and acceptance criterion

NDT should be carried out after sufficient time has elapsed since welding. Time delay after welding should follow applicable NDT standards accepted by IRS.

6.7.1 NDT method

Table 6.7.1 : NDT method		
Base material	**Surface**	**Internal**
Ferro-magnetic material (ferrite steel)	VT, MT, PT, ET[1)]	RT[2)]
Non-ferromagnetic material (austenitic steel, aluminium alloy, copper alloy)	VT, PT, ET	

Note:
1) VT refers to visual testing, MT refers to magnetic particle testing, PT refers to penetration testing, ET refer to eddy current testing,
2) An approved ultrasonic testing procedure may be accepted, e.g., Phased-Array Ultrasound Testing (PAUT) (refer IRS Classification Notes: Requirements for Non-Destructive Testing, Sec.2), at IRS discretion, in lieu of radiographic testing when the conditions are such that a comparable level of weld quality is assured.

6.7.2 NDT requirements

Table 6.7.2 : NDT requirement				
Pipe Class	**Joint Type**	**OD**	**NDT Method**	**NDT requirement[3)]**
any	any	any	VT	100%
I	Butt-welded	OD > 75[mm]	RT[1)]	100%RT
		OD ≤ 75[mm]		10%RT random
II		OD > 100[mm]		
I	Fillet weld of flange pipe connection[2)]	any	MT or PT[4)]	100%MT, or other NDT methods

Note:
1) An approved ultrasonic testing procedure may be accepted, e.g. PAUT, at IRS discretion, in lieu of radiographic testing when the conditions are such that a comparable level of weld quality is assured.
2) In other cases, magnetic particle examination or equivalent non-destructive testing may be required at the discretion of the Surveyor.
3) Ultrasonic examination in addition to the above non-destructive testing may be required in special cases at IRS discretion.
4) For non-magnetic materials penetrant testing may be used.

6.7.2.1 Radiographic and ultrasonic examination should be performed with an appropriate technique by trained operators according to recognized standards. Complete details of the radiographic or ultrasonic technique should be submitted for approval upon request.

6.7.2.2 Magnetic particle examination should be performed with suitable equipment and procedures, and with a magnetic flux output sufficient for defect detection. The equipment may be required to be checked against standard samples.

6.7.2.3 NDT timing for examination of welds delayed cracking considers mainly the yield strength level and thickness of materials to be welded. For carbon and carbon-manganese steel with thicknesses greater than 30 [mm] and for alloy steels the NDT should be carried out not earlier than 48 hours after completion of the welds in question. For carbon and carbon-manganese steels with thicknesses 30 [mm] and less the time limit may be reduced to 24 hours.

6.7.3 Acceptable standard level

6.7.3.1 The welds should comply with the acceptable standard level as specified in Table 6.7.3.1.

Table 6.7.3.1 : Acceptable standard level

NDT Method	Standard	Pipe class	Acceptable Level
RT	ISO 10675-1	I	1
		II, III	2
	EN 12517-1	I	1
		II, III	2
	CB/T 3558	I	II
		II, III	III
	JIS Z3104	I	II
		II, III	III
UT	ISO 11666	I	2
		II, III	3
	EN ISO 11666	I	2
		II, III	3
	CB/T 3559	I	II
		II, III	III
	JIS Z3060	I	II
		II, III	III
MT	ISO 23278	I	2X
	EN ISO 23278	I	2X
	CB/T 3958	I	II
		II, III	III
PT	ISO 23277	I	2X
	EN ISO 23277	I	2X
	CB/T 3958	I	II
		II, III	III

6.7.3.2 Weld colour should be checked after welding but before clean-up for stainless steel and non-ferrous metal as recommended in Table 6.7.3.2.

Table 6.7.3.2 : Weld colour check for stainless steel and non-ferrous metal

Pipe class	Weld colour	Criteria
I, II, III	Silver white	Acceptable
I, II, III	Golden	Acceptable
I, II, III	Light blue	Acceptable
II, III	Blue, dark blue	Acceptable
I, II, III	Gray, black	Not acceptable

6.8 Weld remedy

6.8.1 Unacceptable defects should be removed and repaired to the satisfaction of IRS

Section 7

Installation Onboard

7.1 Piping should be installed in accordance with the approved piping drawings. Piping installation includes the supply and installation of supports shown in the drawings and piping schedules together with those supports necessary to adequately and properly secure the piping. All lines should be installed true and plumb except where specifically noted on the drawings.

7.2 Installation of piping should be scheduled so that no undue strain will be inflicted on equipment due to lack of support, dead weight, or misalignment.

7.3 Piping should be made, broken, and re-made at all rotating equipment connecting points, with alignment checks made with and without pipe in order to prove piping does not affect alignment. Flange bolts should be tightened evenly and sequentially to avoid distortion or overstressing of equipment. If any piping does not meet alignment checks, the Yard should cut and refit that pipe.

7.4 In special cases, when approved by IRS, heating and stress relieving of the pipe may be allowed to make final fit-up. No heating or bending may be done except by using approved procedures.

7.5 Pipe should be installed beginning at the equipment connection then moving away as the piping is assembled. Where required, field welds should be used when installing pipe to equipment.

7.6 Field modification of prefabricated piping should be performed in accordance with this document and the applicable codes, standard or recommended practice.

7.7 All weld burrs and foreign matters should be removed from the piping prior to closure. Construction supports required during installation should be provided by the Yard and should be clearly marked by the Yard for removal before commissioning.

7.8 The Yard should take all possible care to avoid contamination of stainless-steel materials. Austenitic stainless-steel pipe and fittings and all valves and special items should be stored out of contact with the ground. Valves and special items should also be covered to prevent entry of moisture or foreign matter. Stainless steel materials should be lifted with nylon or other approved slings, which are free from dirt or ferritic particles. Under no circumstances should chains or wire ropes be used.

7.9 Shoes and cradles should preferably be located and attached to the pipe work after the line has been installed. They may be attached to pipes prior to installation provided that when the pipe is installed the shoes and cradles are central over the pipe supports.

7.10 To prevent damage to valve seal and seat surfaces, valves, when installed, should be, and should be left in, the following open/close positions:

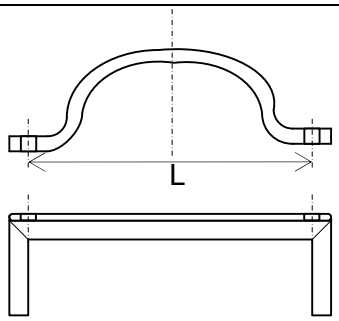
- Ball and plug valves - fully open.
- Globe and gate valves - fully closed.

7.11 Piping should not be connected to a valve of any description unless the joints can be made without inducing stress in either the valve or the pipe work. Temporary strainers, slip-plates, blind flanges, and the like should be properly installed in the location manner and orientation shown in the drawings.

7.12 Pipe Support

7.12.1 The pipe support should not be welded to shell plate directly. Where supports are welded to local supporting members or primary supporting members, they should be kept clear of end supports, toes of brackets and similar stress raisers. The welding should be at least 25 [mm]away from the edge of the web. In the case of flanged structures, the connection may be made to the web or to the centerline of the face plate, but well clear of the free edges.

Table 7.12 : Pipe support arrangement

Item		Standard range	Limited range	Remark
 L: Bolt hole distance offset between shell plating type clamp and pipe support	L	0~2[mm]	--	--

7.13 Pipe support spacing

7.13.1 Selection and spacing of pipe supports in shipboard systems should be determined as a function of allowable stresses and maximum deflection criteria. The selection and spacing of pipe support should consider 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 should be considered. (See figure 7.13 for general view)

7.13.2 Each support should evenly distribute the load of the pipe and its contents over the full width of the support. Measures such as pad or anti-scratch bar should be taken to minimize wear of the pipes where they contact the supports.

7.13.3 Heavy components in the piping system such as valves and expansion joints should be independently supported.

Note: The spacing might be adjusted flexibly within a certain reasonable range considering the onboard layout (e.g., frame space of hull structure) to facilitate construction, provided the provisions of 7.13.1 to 7.13.3 above have been complied with.

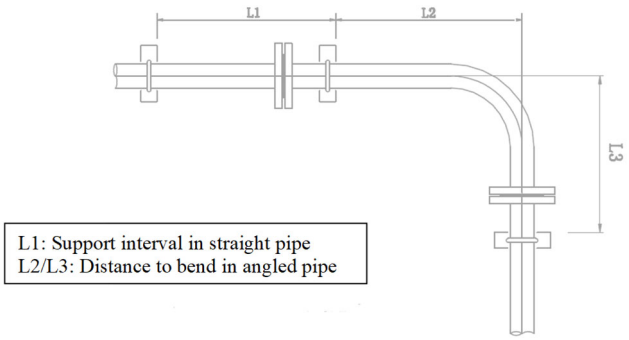


Fig. 7.13 : Pipe Support Interval

Table 7.13 a) : Support interval in straight pipe (L1) (Limit ≤1.2 L1(standard))			
Pipe		**Max. interval, [m]**	
DN, [mm]	**O.D., [mm]**	**Steel Pipe**	**Non-ferrous Pipe**
6	-	-	1.0
8	-	-	1.0
10	17	-	1.0
15	20	-	1.2
15	22	1.2	-
25	30	-	1.5
25	34	1.5	-
32	35	-	1.5
32	42	1.5	-
40	45	-	2.0
40	48	2.0	-
50	60	2.0	2.0
65	76	2.0	2.0
80	89	2.5	2.0
100	114	2.5	2.0
125	140	3.2	2.5
150	168	3.6	3.0
200	219	4.0	3.5
250	273	4.0	3.5
300	325	4.0	3.5
350	355	4.0	3.5
400	406	4.8	4.0
450	457	4.8	4.0
500	508	4.8	4.0
550	558	5.6	-
600	610	5.6	-
650	660	5.6	-
700	711	5.6	-
800	813	6.4	-
850	864	6.4	-
900	914	6.4	-
950	965	6.4	-
1000	1016	6.4	-

Table 7.13 b) : Distance to bend in angled pipe (L2/L3)					
Pipe size		**Standard distance of pipe support [mm]**			
DN	**OD**	**Steel pipe**		**Non-ferrous Pipe**	
		L2	**L3**	**L2**	**L3**
10	14	-	-	-	-
15	22	700	350	800	200
20	27	800	360	800	200
25	34	1000	370	800	200
32	42	1100	390	800	200
40	48	1250	400	1200	300
50	60	1300	420	1200	300
65	76	1450	450	1200	300
80	89	1500	480	1250	350
100	114	1800	530	1250	350
125	140	2000	580	1300	400
150	168	2100	640	1300	400
200	219	2350	730	-	-
250	273	2400	840	-	-
300	325	2450	940	-	-
350	377	2500	1000	-	-
400	426	3000	1100	-	-
450	480	3100	1200	-	-
500	530	3250	1300	-	-

7.13.4 For pipes connected to valves, filters, expansion joints, etc., supports should be provided nearby. The preferred distance is 200[mm]~1000[mm]. (Figure 7.13.4)

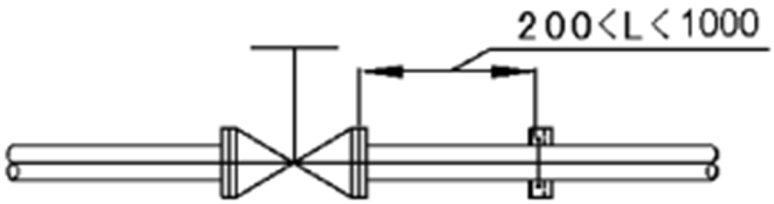
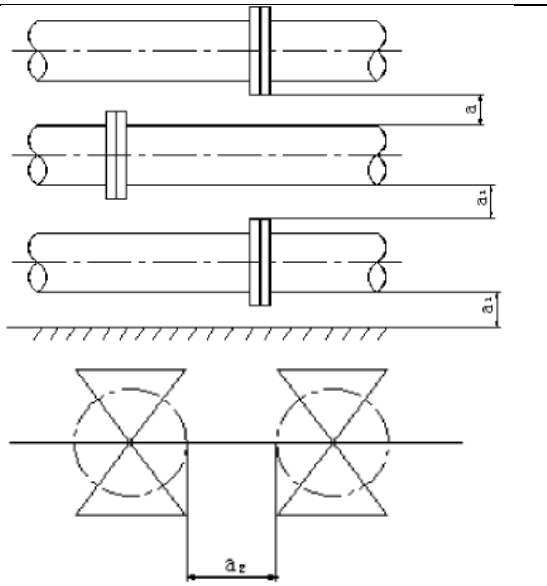


Fig. 7.13.4 : Distance between valve and pipe support

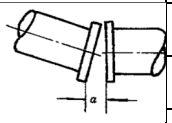
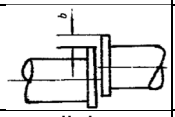
7.13.5 For unfixed low end of pipe, such as suction pipe, sounding pipe, filling pipe and drain pipe, etc., supports should be provided near their ends. The position should be determined according to the pipe diameter and accessory weight. The preferred distances are within 150[mm]~1000[mm]from the ends.

7.14 Gap between piping

Table 7.14 : Gap between piping

Item		Standard [mm]	Limit [mm]	Remark
	a: Distance between parallel or cross pipes, adjacent pipes (incl. fitting)	>20	>10	
	a1: Distance between pipe with thermal insulation, adjacent pipes and hull structure	>20	>10	
	a2: Distance between adjacent valve hand wheels	≥30		
	a3: distance between hot pipe and cable	≥150	100	
	Longitudinal shift between anti-scratch bar and pipe support (outside coating pipe)	≤L18/3		

7.15 Piping Installation

Table 7.15 : Piping installation					
Item		**Standard**		**Limit**	**Remark**
	Remaining threads after fastened	1~3 pitches		1/2 of bolt diameter	-
Permitted gasket quantity between flanges		1		1	
Permitted bolt washers		2			
parallel deviation between flanges at free condition		DN≤100	<1.0	Bolt can get through freely	Forcible alignment is prohibited.
		DN>100~200	<2.0		
		DN>200~400	<3.0		
		DN>400	<4.0		
		≤1.5			
Flange deviation between pipe and piping equipment at free condition SAG&GAP	parallel	<3000 [rpm]	≤0.40[mm]		Equipment manufacturer's requirement is premier.
		3000~6000 [rpm]	≤0.15[mm]		
		>6000[rpm]	≤0.10[mm]		
	concentricity	<3000[rpm]	≤0.80[mm]		
		3000~6000[rpm]	≤0.50[mm]		
		>6000[rpm]	≤0.20[mm]		

7.16 Flushing

7.16.1 Prior to commencing any flushing, the yard should verify that all required non-destructive testing (NDT) such as radiography, ultrasonic, etc., has been completed. The yard should also verify that all required post-weld heat-treating has been completed. All completed piping systems should be flushed prior to testing.

7.16.2 All piping DN50 and larger, other than instrument and utility air, should be flushed with fresh water to completely clean them of any loose mill scale, rust, or various extraneous materials. All piping smaller than DN50, and air lines of any size, should be cleaned out in like manner using compressed air.

7.16.3 The flushing should be done at as a high a velocity as practical (minimum of 1.5 m/sec.) in order to flush out any loose material in the line. Flanges should be opened, and spool pieces should be removed as necessary to flush the piping thoroughly.

7.16.4 Flushing should be performed until a clear stream of flushing medium exits the piping, with minimum flush volume being equal to five (5) times the volume of the piping being flushed. Orifice plates, thermo wells, flow straightening vanes, positive displacement (PD) and turbine meters and other vulnerable equipment, if already installed, should be removed prior to flushing.

7.16.5 All instrument leads should be disconnected prior to flushing and should remain disconnected during pressure test.

7.16.6 All control valves should be removed. Spring type supports should have stops installed to prevent overloading of the support. All vessels included within a piping system being flushed should be filled and drained through the vessel drain system.

7.16.7 All check valve clappers should be removed and attached to the outer body of the valve for the test duration. Refer to Table 7.16.7 for further details.

Table 7.16.7 : Cleanliness levels for Piping systems

Piping system		**Standard***	**limit**	**Remark**
M.E. Lubricating oil		20/19/16	-	Manufacturer's instruction takes precedence.
Stern tube Lubricating oil		19/18/15	-	
Diesel FO injection		18/17/14	-	
Hydraulic oil for windlass and winch	High pressure section	19/18/15	-	
	Low pressure section	20/19/16	-	
Hydraulic oil for steering gear, hatch and bow door		19/18/15	-	
Note*: code see ISO 4406				

End of Guidelines