CHINA CLASSIFICATION SOCIETY

RULES FOR MATERIALS AND WELDING

AMENDMENTS

2023

Effective from 1 July 2023

Beijing

Table of Contents

PART ONE METALLIC MATERIALS

CHAPTER 2 MATERIAL TESTS

Section 7 INTERGRANULAR CORROSION TESTS OF STAINLESS STEEL

2.7.3 Testing

2.7.3.1 The corroding media solution used for the test is to be prepared as follows:

(1) put 100 g copper sulphate ($CuSO_4 \cdot 5H_2O$) into 700 ~~ml~800~~ ml distilled water;

(2) add 100 ml pure sulphuric acid (relative density 1.84 g/ml) in accordance with relevant international provisions slowly into the solution mentioned in (1);

(3) dilute the solution mentioned in (2) up to 1 L with distilled water.

2.7.3.2 Fine copper turnings are to be put into a test vessel to form a bed of copper turnings, and the ratio of the copper turnings to the solution is at least 50 g/L.

2.7.3.3 For ultra-low carbon stainless steel (carbon content not more than 0.03%) and stabilized stainless steel (titanium or niobium added), c~~C~~leaned specimens are to be subject to sensitization heat treatment (except for weld joint specimen): for ultra-low carbon stainless steel and stabilized stainless steel, austenitic stainless steel is to be heated to a temperature of 650±10℃ for 120 min, followed by cooling in air. Austenitic/ferrite duplex stainless steel is to be heated to a temperature of 700 ±10℃ for 30 min, followed by rapid cooling in water. They are then to be positioned on the bed of copper turnings in the test vessel. Add the corroding media solution to immerse the entire specimen and the solution is to be at least 20 mm higher than the surface of the specimen. Heat the test vessel till the solution boils, so that the specimen is immersed in the boiling solution for 16 h, unless for a longer time agreed between the supplier and the user. Precautions are to be taken to prevent concentration of the solution by evaporation. Where multiple specimens are positioned in the vessel, the ratio between total volume of the solution and total surface area of the specimens is not to be less than 10 ml/cm^2, and there is to be no contact between specimens.

Weld joint specimens that are solution annealed after welding are to be subject to sensitization heat treatment before the test.

CHAPTER 5 STEEL FORGINGS

Section 1 GENERAL PROVISIONS

5.1.3.8 Where two or more forgings are joined by welding to form a composite component, or the forgings are joined with other steel members by welding to form a composite component, the welding procedure specification is to be submitted to CCS for approval. ~~If necessary, w~~Welding procedure approval tests ~~may~~are to be required.

5.1.3.9 Welders intended to be engaged in welding of steel forgings for hull structures are to obtain certificates of qualification issued or accepted by CCS.

5.1.4.4 Where a forging is subject to local heating and hot or cold straightening, after the final heat treatment, a subsequent stress relief heat treatment is to be considered. The manufacturer is to have strict control of stress relief heat treatment temperature to (not higher than tempering temperature) in order to avoid any detrimental effects to the final heat treatment and resultant microstructure and mechanical properties of the forging.

5.1.4.7 It is the manufacturer's responsibility to select the appropriate heat treatment method in order to meet the design and application requirements for steel forgings.

5.1.5.5 ~~Unless specified otherwise, w~~When a test specimen is taken, ~~the longitudinal axis of~~ the specimen is to be positioned as follows:

(1) For forgings having a thickness, t, or diameter D up to maximum 50mm, the longitudinal axis of the test specimen is to be located at the mid-thickness (a distance of t/2 below the heat treated surfaces) or the center of

the cross section (D/2). ~~For thickness or diameter up to maximum 50 mm, the axis is to be at the mid-thickness or the center of the cross section.~~

(2) Test specimen is to be located with its longitudinal axis at a distance from any heat treated surface. For forgings having a thickness, t, or diameter D greater than 50mm, the longitudinal axis(middle) of the test specimen is to be located at a distance of t/4 or D/4 (mid-radius) or 80mm, whichever is less, below any heat treated surface. ~~For thickness or diameter greater than 50 mm, the axis of the middle of the specimen is to be at one quarter thickness (mid-radius) or 80 mm, whichever is less, below any heat treated surface.~~

(3) For ring and disc forgings (noting that the test specimen locations for these shaped forgings may be different to other free form forgings):

tangential sample is to be taken at t/2 for thickness ≤ 25mm, in both the vertical and horizontal direction.

tangential sample is to be taken at 12.5mm below the heat treated surface for thickness >25mm, in both the vertical and horizontal direction.

(4) Where achievable, for thickness >25mm, no part of the test material is to be closer than 12.5 mm to any heat treated surface, as shown in Fig. 5.1.5.5.

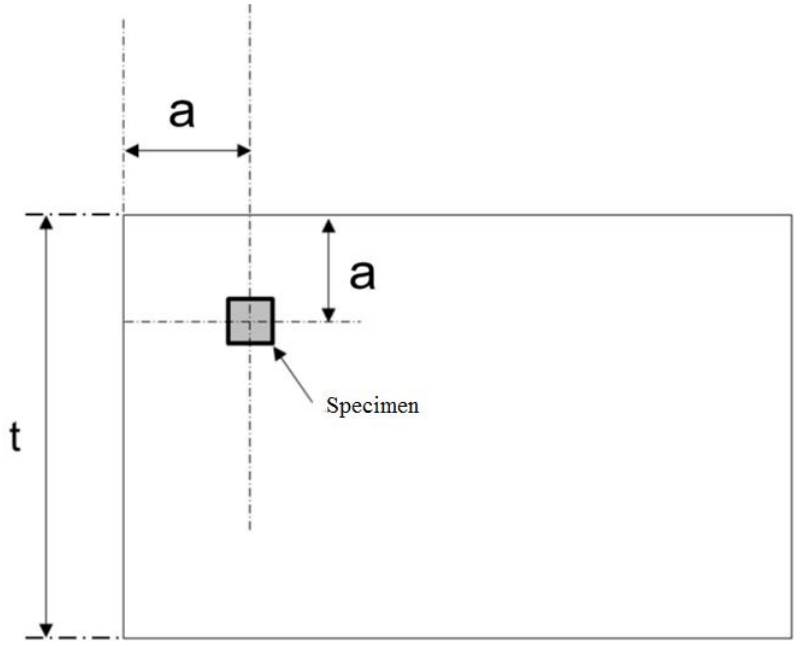


Figure 5.1.5.5 Position of the test specimen

5.1.6.1 Before acceptance, all forgings are to be subjected to a 100% visual examination of all accessible surfaces by the manufacturer ~~presented to the Surveyor for visual examination~~. Where applicable, this is to include the examination of internal surfaces and bores. Unless otherwise agreed, the manufacturer is to be responsible for checking the accuracy of dimensions of forgings.

5.1.6.4 Non-destructive testing is to be carried out after the forgings have been machined to a condition suitable for this type of examination and after the final heat treatment, and the following requirements are to be complied with:

(1) the test methods and extent are to comply with the requirements of Appendix 7A, Chapter 7 of CCS Guidelines for Inspection of Hull Welds;

(2) where current flow methods are used for magnetization, particular care is to be taken to avoid damaging machined surfaces by contact burns from the prods;

(3) radial and axial scanning is generally to be carried out when carrying out ultrasonic examination. When the dimensions and shape are limited, radial or axial scanning may be carried out;

(4) unless specified by the plan or otherwise agreed, the results of non-destructive testing are to comply with the requirements of Appendix 7A, Chapter 7 of CCS Guidelines for Inspection of Hull Welds or relevant recognized standards.

(5) For mass produced forgings the extent of examination may be established at the discretion of CCS.

5.1.6.5 If the forging is supplied in the “as forged” condition, the manufacturer is to ensure that a suitable ultrasonic examination is carried out on the forging to verify the internal quality of the forging.

5.1.6.6 Where advanced non-destructive testing methods(ANDT) are applied, the requirements of Appendix 2

of PART THREE of the Rules for Materials and Welding are to be complied with.

5.1.6. ~~5~~7 Unless agreed by CCS Surveyor, these tests are to be carried out in the presence of the CCS Surveyor.

5.1.8.2 All forgings which have been satisfactorily inspected by CCS are to be clearly marked by the manufacturer in at least one place with the following:

(1) CCS logo;

(2) cast number or other marking which will enable the full history of the forging to be traced;

(3) test pressure (if any);

(4) brand or grade of forging material;

(5) date of final inspection ~~abbreviated name of the survey unit and personal stamp of Surveyor responsible for inspection~~;

(6) certificate number.

When the area is not enough for all marks, at least the items (1) to (3) are to be marked.

Any mark is to be encircled with paint for easy recognition.

Section 2 FORGINGS FOR HULL STRUCTURES

5.2.3 Heat treatment

5.2.3.1 Unless otherwise provided, forgings are to be supplied in one of the following conditions:

(1) fully annealed;

(2) normalized;

(3) normalized and tempered (tempered at a temperature not less than 550℃);

(4) quenched and tempered (tempered at a temperature not less than 550℃).

5.2.3.2 Unless otherwise provided, alloy steels are to be supplied in one of the following conditions: ~~in the quenched and tempered condition (tempered at a temperature not less than 550℃).~~

(1) fully annealed;

(2) normalized;

(3) normalized and tempered (tempered at a temperature not less than 550℃);

(4) quenched and tempered (tempered at a temperature not less than 550℃).

5.2.4 Mechanical properties

5.2.4.1 Preparation of test specimens for forgings

(1) At least one tensile specimen is generally to be taken from each forging in a longitudinal direction and a set of three impact test specimens are to be taken. At the discretion of the manufacture, the alternative directions or positions as shown in Figure 5.3.4.4 may be used.

(2) Where a forging exceeds both 4000 kg in mass and 3 m in length, tensile test specimens are to be taken from each end and a set of three impact test specimens are to be taken. These limits refer to the "as forged" mass and length but excluding the test material.

5.2.4.2 The results of all tensile tests of steel forgings are to comply with the requirements given in Table 5.2.4.2.

For large forgings, where tensile tests are taken from each end, the variation in tensile strength is not to exceed 70 N/mm^2.

Mechanical Properties for Hull Steel Forgings **Table 5.2.4.2**

Steel type	Tensile strength①② R_m min. (N/mm^2)	Yield strength R_{eH} min. (N/mm^2)	Elongation A_5 min. (%)		Reduction of area Z min. (%)		Charpy V-notch impact test Minimum average energy③ (J)		
			Long.	Tang.	Long.	Tang.	Test temperature (°C)	Long.	Tang.
Carbon and carbon-manganese	400	200	26	19	50	35	0	27	18
	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			

Notes: ① For forgings with a specified minimum tensile strength < 600 N/mm², the tensile strength range may be ~~is~~ 120 N/mm²; for forgings with a specified minimum tensile strength ≥ 600 N/mm², the tensile strength range may be ~~is~~ 150 N/mm².

② 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.

③ Alternative acceptance requirements may be accepted, depending on design and application, and subject to agreement of CCS.

④ For ships navigating in ice with an Ice Class Notation B1*,B1, B2 and B3, the forgings for the hull structure exposed to air are, in addition to the tests required by 5.2.4.1 of this Section, to be subjected to Charpy V-notch impact tests at -10℃. A set of three impact test specimens is to be provided, and the average longitudinal impact energy is not to be lower than 20 J.

~~5.2.4.3 For ships navigating in ice with an Ice Class Notation B1* or B1, the forgings for the rudder stock, axle or pintle are, in addition to the tests required by 5.2.4.1 of this Section, to be subjected to Charpy V-notch impact tests at -10°C. A set of three impact test specimens is to be provided, and the average longitudinal impact energy is not to be lower than 27 J.~~

Section 3 FORGINGS FOR SHAFTING AND MACHINERY

Chemical Composition of Forgings for Shafting and Machinery **Table 5.3.2.1**

Steel type	Chemical composition (%)									
	C	Si	Mn	S	P	Cr	Mo	Ni	Cu②	Total residuals
Carbon and carbon-manganese	≤~~0.65~~0.23①⑤	≤ 0.45	0.30~1.50	≤ 0.035	≤ 0.035	≤ 0.30②	≤ 0.15②	≤ 0.40②	≤ 0.30	≤ 0.85
Alloy③	≤ 0.45	≤ 0.45	0.30~1.00	≤ 0.035	≤ 0.035	≥ 0.40④	≥ 0.15④	≥ 0.40④	≤ 0.30	–

Notes: ① The carbon content of carbon and carbon-manganese steel forgings intended for welded construction is to be 0.~~23~~65% maximum. ~~The carbon content may be increased above 0.23% provided that the carbon equivalent (Ceq) is not more than 0.41%, calculated using the following formula:~~

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

② The carbon content may be increased above 0.23% provided that the carbon equivalent (Ceq) is not more than 0.41%, calculated using the following formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

~~②~~③ Elements are considered as residual elements unless shown as a minimum.

~~③~~④ Where alloy steel forgings are intended for welded constructions, the proposed chemical composition is subject to approval by CCS.

~~④~~⑤ One or more of the elements is to comply with the minimum content.

5.3.3 Heat treatment

5.3.3.1 Carbon or carbon-manganese steel forgings are to be heat treated as follows:

(1) fully annealed; or

(2) normalized; or

(3) normalized and tempered; or

(4) quenched and tempered.

The tempering temperature is not to be less than 550℃.

Forgings having a tensile strength exceeding 700 N/mm² are to be quenched and tempered.

5.3.3.2 Alloy steel forgings are to be heat treated as follows:

(1) normalized;

(~~1~~2) quenched and tempered; or

(~~2~~3) normalized and tempered.

The tempering temperature is not to be less than 550℃.

~~Where alloy steel forgings are supplied in the normalized and tempered condition, the mechanical properties are to be in compliance with the requirements of recognized international or national standards.~~

5.3.4.3 The tests and number of test specimens for forgings are to comply with the requirements of Table 5.3.4.3.

Tests and Number of Test Specimens of Forgings for Shafting and Machinery Table 5.3.4.3

Forgings	Tests and number of test specimens	
	Carbon and carbon-manganese steel	Alloy steel
Intermediate shafts, thrust shafts, tube shafts, screwshafts, connecting rods, piston rods, crossheads, supercharger rotor shafts, forgings for shafts, studs of cylinder heads, tie bolts, main bearing studs, shaft coupling bolts, top and bottom end bolts of connecting rods, suction and exhaust valves, important forgings for the transmission of shafting	1. Chemical analysis 2. Tensile test, at least one test specimen 3. impact test, at least a set of three test specimen	1. Chemical analysis 2. Tensile test, at least one test specimen 3. Impact test, at least one set of three test specimens 4. Inclusion analysis①

Note: ① Applicable to intermediate shaft forgings specified by 5.3.4.5 of this Section.

5.3.5.1 The mechanical properties of forgings for shafting and machinery are to comply with the requirements of Table 5.3.5.1.

Mechanical Properties of Forgings for Shafting and Machinery Table 5.3.5.1

Steel type	Tensile strength①② R_m min. (N/mm²)	Yield stress R_{eH} or $R_{p0.2}$ min. (N/mm²)	Elongation A_5 min. (%)		Reduction of area Z min. (%)		Hardness③ (HB)	Charpy V-notch impact test Minimum average energy④⑥ (J)		
			Long.	Tang.	Long.	Tang.		Temperature (°C)	Long.	Tang.
Carbon and carbon-manganese	400	200	26	19	50	35	110~150	AT⑤	27	18
	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			

Notes: ① For forgings with a specified minimum tensile strength < 900 N/mm², the tensile strength range may be ~~is~~ 150 N/mm²;
for forgings with a specified minimum tensile strength ≥ 900 N/mm², the tensile strength range may be ~~is~~ 200 N/mm².

② 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.

③ Hardness values are given for information purposes only.

④ Alternative acceptance requirements may be accepted, depending on design and application, and subject to agreement of CCS.

⑤ AT refers to ambient temperature for the impact test (i.e. 23°C±5°C).

⑥ For ships navigating in ice with an Ice Class Notation B1*, B1, B2 and B3, the forgings for machinery exposed to sea water temperature are to be subject to Charpy V-notch impact tests at -10℃. A set of three impact test specimens is to be provided, and the average impact energy is not to be lower than 20 J.

~~5.3.5.3 For ships navigating in ice with an Ice Class Notation B1* or B1, the forgings for the screwshaft of all steel types listed in Table 5.3.5.1 are to be subject to Charpy V-notch impact tests at -10℃. A set of three impact test specimens is to be provided (from the propeller end of each shaft), and the average impact energy is not to be lower than 27 J.~~

5.3.5.4~~2~~3 Where tensile test specimens are taken from different positions of a forging, the variation in tensile strength is not to exceed the following:

Tensile strength (N/mm^2)	Difference in tensile strength (N/mm^2)
< 600	≤ 70
≥ 600	≤ 100

Section 4 FORGINGS FOR CRANKSHAFTS

5.4.6.2 The Charpy V-notch impact tests for alloy steel forgings for crankshafts ~~at ambient temperature~~ are to comply with the requirements of Table 5.3.5.1 and Table 5.4.6.2.

Impact Test Requirements for Alloy Forgings for Crankshafts at Ambient Temperature ①

Table 5.4.6.2

Specified min. tensile strength Rm (N/mm^2)			600	700	800	900	1000	1100
Minimum average energy (J) for Charpy V-notch impact test	Normalized and tempered	Long.	~~25~~27	~~20~~27	~~15~~27	–	–	–
		Tang.	~~15~~18	~~12~~18	~~9~~18	–	–	–
	Quenched and tempered	Long.	41	32	30	27	~~25~~27	~~21~~27
		Tang.	24	22	20	18	~~16~~18	~~13~~18

Note: ① Where it is proposed to use a steel with a specified minimum tensile strength intermediate to those given, corresponding minimum average energy may be obtained by interpolation.

Section 5 FORGINGS FOR GEARING

5.5.5.1 Each forging, from which specimens are to be taken, is to provide test material sufficient for the preparation of at least one group of specimens, including one tensile specimen and a set of three impact specimens. The specimens are to be taken as follows:

(4) For gear wheel rim forgings, test specimens are to be taken in a tangential direction at position A or position B as shown in Figure 5.5.5.1(4). Where the finished diameter exceeds 2.5 m or the mass (as heat treated ~~but excluding~~ including test material) exceeds 3 t, test specimens are to be taken from two diametrically opposite positions, i.e. position A and position B, as shown in Figure 5.5.5.1(4). The mechanical properties of test specimens are to be in compliance with the longitudinal requirements.

(6) Test positions for forged rings (such as slewing rings) are shown in Figure 5.5.5.1(6).Test specimens of different types of forged rings are to be taken in a tangential direction from the part that can be cut in position A or B. Where the finished diameter exceeds 2.5 m or the mass (as heat treated, including test material) exceeds 3 tonnes then two sets of test specimens are to be taken diametrically opposite position.

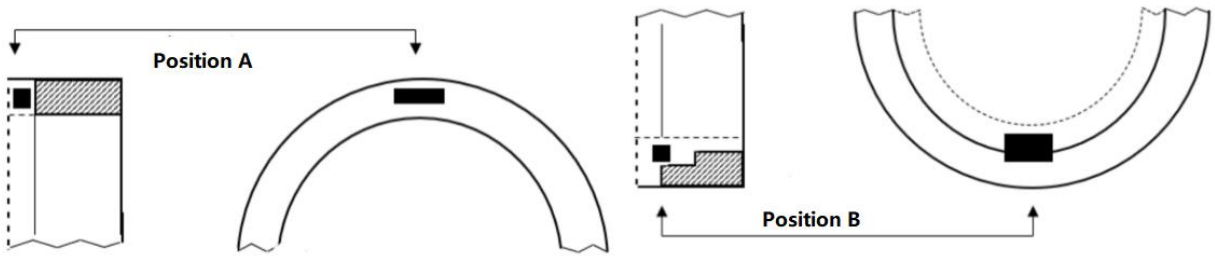


Figure 5.5.5.1(6)

CHAPTER 6 STEEL CASTINGS

Section 1 GENERAL PROVISIONS

6.1.1.1 This Chapter applies to steel castings intended for use in the construction of ships and offshore installations~~, machinery, boilers, pressure vessels and piping systems~~.

6.1.1.3 Unless provided otherwise in Section 6 to Section 8, the provisions of this Chapter are applicable ~~only~~ to steel castings for welding and non-welding purposes ~~where the design and acceptance tests are related to mechanical properties at ambient temperature~~. Where required by designs and applications, necessary additional tests may be required, especially when the castings are intended for service at low or elevated temperatures.

6.1.2.3 Where two or more castings are joined by welding to form a composite item, details of the proposed welding procedure specification are to be submitted to CCS for approval~~.~~ and ~~W~~welding approval procedure tests are to be carried out ~~may be required when necessary~~. Welders are to be examined in accordance with the requirements of Chapter 4 of PART THREE and are to obtain a certificate of qualification issued or accepted by CCS.

6.1.2.5 Temporary welds made for operations such as lifting, handling, etc., are to be welded in accordance with approved welding procedures by qualified welders, and are to be removed, ground and inspected using suitable NDT methods.

6.1.4.2 The content of grain refining elements adopted by the manufacturer is to be at the discretion of the manufacturer or as agreed with by CCS ~~reported in the ladle analysis~~.

6.1.6.1 Test material sufficient for the required tests and for possible re-test purposes is to be provided for each casting or batch of castings. The test blocks are to be representative of the properties of the entire casting. The test samples are to be either integrally cast or gated to the casting and are to have a thickness (t_s) of not less than the ruling section of the casting (by referring to ISO4990, ISO683-1, ISO683-2 or determined by test) or 30 mm (whichever is greater). In the case of quenched and tempered thin-walled steel castings, the thickness of the test sample is to be at least 20 mm, and is to be appropriate to the thickness of the casting.

6.1.6.2 As shown in Figure 6.1.6.2, for large thickness castings other than stern tube, stern frame, anchor and rudder horn, t_s normally need not to exceed 150 mm. Length and width of the test block is normally to be at least three times t_s, unless otherwise agreed with by CCS. Shorter width or length may be accepted for test blocks where actual casting width or length is in the range between t_S and $3t_S$. For alloy steel castings the manufacturer is to propose dimensions for the test block which is to be agreed with by CCS.

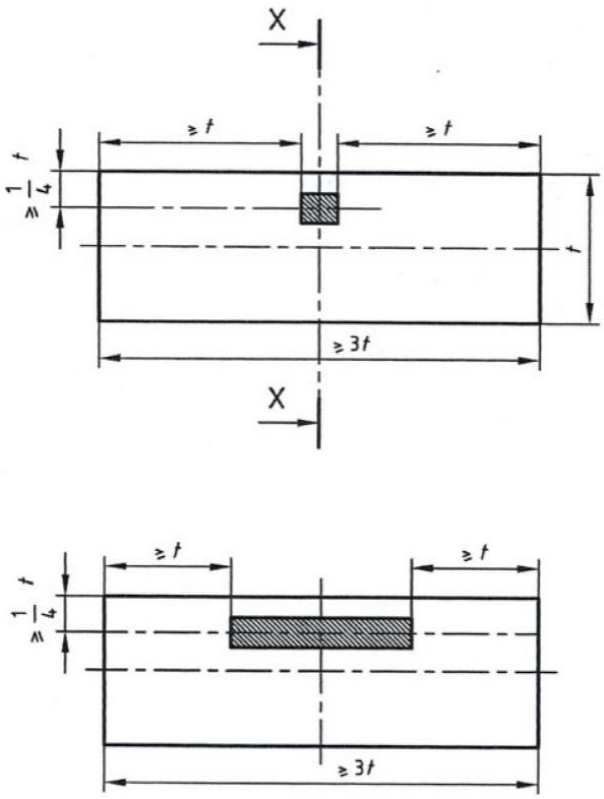


Figure 6.1.6.2 Specimen positions relative to the test block in accordance with ISO 4990

6.1.6.~~2~~3 The test samples are not to be detached from the castings until heat treatment has been completed and they have been properly identified.

6.1.6.~~3~~4 For a number of small castings submitted for batch testing as specified in 6.1.1.5 of this Section, the test samples may be separately made from the same cast. The size of test samples is to be determined in accordance with a recognized standard (e.g. ISO 4990) and not to be less than ~~at least to be~~ 28 mm in thickness. Test samples are to be properly identified and heat treated together with the castings they represent.

6.1.6.~~4~~5 ~~The test specimens are to be taken where the axis is at 1/4 of thickness of test samples.~~ Where the thickness of test samples is less than or equal to 56 mm, the axis of test specimens is to be taken at 14 mm from the surface. For test blocks with thickness > 56 mm, the longitudinal axis of the test specimens is to be located at ≥ ¼ t_s from the surface. As shown in Figure 6.1.6.2, other parts of the test specimens taken are to be located not less than t_s from the surface. All test specimens are to be prepared in accordance with the requirements of Chapter 2 of this PART. Tensile test specimens are to have a cross-sectional area of greater than 150 mm^2.

~~6.1.10.1 The defects of castings may be classified based on the extent of weld repairs:~~

~~(1) Major repairs are those where the depth is greater than 25% of the wall thickness or 25 mm, whichever is less, or where the total weld area on a casting exceeds 2% of the casting surface noting that where a distance between two welds is less than their average width, they are to be considered as one weld.~~

~~(2) Minor repairs are those where the total weld area (length × width) exceeds 500 mm2.~~

~~(3) Cosmetic repairs are all other welds not included in (1) and (2) above.~~

~~(4) Castings subject to the removal of defects may be supplied without welding on un-machined surfaces where the depth of defect removal is not over 15 mm or 10% of wall thickness, whichever is less, and the length of the removed part is not over 100 mm.~~

6.1.10.1 Where castings are to be repaired, the manufacturer is to exercise robust controls of all repair operations regarding the repair of castings, with respect to dimensions, heat treatment, inspection and quality control. The agreement of CCS is to be obtained where steel castings from which defects were removed are to be used with or without weld repair.

6.1.10.2 Defects must be repaired as indicated below: ~~Defects found in castings are to be removed by one of the following methods:~~

~~(1) grinding, machining;~~

~~(2) chipping and grinding;~~

~~(3) flame-cutting or arc-air gouging and grinding.~~

(1) Defective parts of material may be removed by grinding, machining, or by chipping and grinding, or by arc air-gouging and grinding. Thermal methods of metal removal are only to be allowed before the final heat treatment.
(2) For C and C-Mn steel castings weld repairs are to be suitably classified as follows:
①Major repairs are those where: the depth is greater than 25% of the wall thickness or 25 mm whichever is less, or the total weld area on a casting exceeds 0.125 m^2(the surface of the castings) noting that where a distance between two welds is less than their average width, they are to be considered as one weld.
②Minor repairs: weld repairs not classified as ①. CCS may request minor repairs in critical areas to be treated as major repairs.
(3) Shallow grooves or depressions resulting from the removal of defects may be accepted subject to agreement by CCS provided that they will cause no appreciable reduction in the strength of the casting or affect the intended use, and the depth of defect removal is not over 15 mm or 10% of wall thickness, whichever is less. Small surface irregularities sealed by welding are to be treated as weld repairs.
6.1.10.3 Complete elimination of the defective material is to be verified by non-destructive testing. Where the defective area is not required to be repaired by welding, the shallow grooves or excavations resulting from the removal of defects are to be blended by grinding and to be smoothly blended to the surface area with a finish equal to that of the adjacent surface, subject to the inspection and acceptance by the Surveyor. Where the defective area is required to be repaired by welding, the excavations are to be suitably shaped to allow good access for welding. All grooves are to have a bottom radius of approximately three times the groove depth. NDT of steel castings after repair is to comply with the requirements of 6.1.8 of this Section.
6.1.10.4 Where defects are removed by ~~flame cutting or~~ arc-air gouging, the castings may be required to be preheated depending on their chemical composition, the dimensions and nature of defects.
6.1.10.5 Where it is proposed to repair defective castings by welding, the welding procedure specification is to be submitted to CCS for approval and is to match the delivery condition of the casting. ~~Major repairs are to be subject to prior approval of the Surveyor .~~ Qualification of welding procedures is to comply with CCS Guidelines for Inspection of Hull Welds or other recognized standards subject to agreement of CCS, e.g. ISO 11970. For steels with C ≥ 0.23% or Ceq ≥ 0.45%, the WPQT on which the WPS is based is to be qualified on a base material having a Ceq as follows: the Ceq of the base material is not to fall below more than 0.02% of the material to be welded.
6.1.10.6 Welding repairs are to be carried out in accordance with the approved procedure specification by qualified welders in the down hand position or a position in which a good welding quality is assured. Welding is to be done in positions free from adverse weather conditions. For major repairs, before welding is started, full details of the extent and location of the repair, heat treatment and subsequent inspection procedures are to be submitted to CCS for approval. Minor repairs, with the exception of alloy steels do not require prior approval.

6.1.10.9 After completion of welding, the C and C-Mn steel castings are to be given either a suitable heat treatment in accordance with the delivery requirements or a stress relieving heat treatment at a temperature of not less than 550℃ ~~, or~~ For alloy steel castings, ~~given~~ the heat treatment is to be agreed with by CCS.The type of heat treatment employed will be dependent on the chemical composition of the casting and the dimensions, positions and nature of the repairs, and is not to affect the properties of the casting. ~~as appropriate according to the chemical composition of castings, repair size, position and feature .~~

6.1.10.11 On completion of post-weld 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 ultrasonic or radiographic testing may also be required depending on the dimensions and nature of the original defect. ~~and further examined by the existing non-destructive method dependent on the dimensions, number and position of the defects as shown on a sketch, so as to ensure that the quality of the repaired area is satisfactory.~~
6.1.10.12 Weld repair of defective steel castings for crankshafts is also to comply with the requirements of Section 4 of this Chapter.
6.1.10.13 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 as well as subsequent survey reports. Results of treatment of various defects repaired by welding are to be confirmed by the surveyor and reports and/or records ~~of non-decorative repairs~~ are to be submitted to the surveyor.

Section 2 CASTINGS FOR HULL STRUCTURES

6.2.1.1 The requirements of this Section apply to carbon ~~or,~~ carbon-manganese or alloy steel castings intended for use in the construction of hull structures.

Chemical Composition of Castings for Hull Structures (%) **Table 6.2.2.1**

Steel type	Applications	Chemical Composition (%)								
		C	Mn①	Si	P	S	Residual elements②			
							Cu	Cr	Ni	Mo
C, C-Mn	Castings for welded construction	≤0.23③	0.50~1.60	≤0.60	≤0.035	≤0.035	≤0.30	≤0.30	≤0.40	≤0.15
	Castings for non-welded construction	≤0.40	0.50~1.60	≤0.60	≤0.035	≤0.035	≤0.30	≤0.30	≤0.40	≤0.15
Alloy	Castings for welded construction	May be accepted according to recognized standards subject to agreement of CCS								
	Castings for non-welded construction	≤0.45	0.50~1.60	≤0.60	≤0.035	≤0.035	Alloying elements④			
							≤0.30	≤0.30	≤0.40	≤0.15

Notes: ① The manganese content is not to be less than 3 times the actual carbon content.

② The total content of residual elements of C and C-Mn castings is to be not more than 0.80%.

③ If carbon equivalent C_{eq} calculated according to following formula is not more than 0.41%, the carbon content of castings may exceed the limit of 0.23%.

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

④ At least one of the elements is to comply with the minimum content.

6.2.3 Heat treatment

6.2.3.1 Carbon and carbon-manganese steel ~~C~~castings are to be heat treated as follows:

(1) fully annealed; or

(2) normalized; or

(3) normalized and tempered at a temperature of not less than 550℃; or

(4) quenched and tempered at a temperature of not less than 550℃.

6.2.3.2 Alloy steel castings are to be heat treated as follows:

(1) normalized; or

(2) normalized and tempered at a temperature of not less than 550℃; or

(3) quenched and tempered at a temperature of not less than 550℃.

6.2.4.1 The test specimens for castings are to be prepared as follows:

(1) The test samples are to be poured from the same cast as the castings. They are to be either integrally cast at locations as widely separated as possible or gated to the casting.

(2) At least one tensile test specimen and a set of three Charpy V-notch impact test specimens are ~~is~~ to be made on at least one test sample representing each casting or batch of castings.

(3) Where the casting is of complex design, or where the finished mass exceeds 10 t, 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 required corresponding to the number of casts involved. These are to be integrally cast at locations as widely separated as possible.

~~(4) Where impact tests are to be carried out in accordance with the requirements of 6.2.4.3, a set of three Charpy V-notch impact specimens is to be taken from the test samples.~~

6.2.4.2 The mechanical properties of castings are to comply with the requirements of Table 6.2.4.2.

Mechanical Properties of Castings intended for Welding for Hull Structures Table 6.2.4.2(a)

Steel type	Tensile strength① ② R_m min. (N/mm²)	Yield strength R_{eH} min. (N/mm²)	Elongation A_5 min. (%)	Reduction of area Z min. (%)	Charpy V-notch impact test minimum average energy③ (J)	
					Temperature(℃)	Minimum average energy (J)
C, C-Mn	400	200	25	40	0	27
	440	220	22	30		
	480	240	20	27		
	520	260	18	25		
	560	300	15	20		
	600	320	13	20		
Alloy	550	355	18	30	0	27
	600	400	16	30		
	650	450	14	30		
	700	540	12	28		

Notes: ① The tensile strength ~~is not to~~ may not exceed that required in the Table plus 150 N/mm².

② 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.

③ Special consideration may be given to alternative requirements, depending on design and application, and subject to agreement by CCS.

Mechanical Properties of Castings not intended for Welding for Hull Structures Table 6.2.4.2(b)

Steel type	Tensile strength① ② R_m min. (N/mm²)	Yield strength R_{eH} min. (N/mm²)	Elongation A_5 min. (%)	Reduction of area Z min. (%)	Charpy V-notch impact test minimum average energy③ (J)	
					Temperature(℃)	Minimum average energy (J)
C, C-Mn	400	200	25	40	AT④	27
	440	220	22	30		
	480	240	20	27		
	520	260	18	25		
	560	300	15	20		
	600	320	13	20		
Alloy	550	340	16	35	AT④	27
	600	400	16	35		
	650	450	14	32		
	700	540	12	28		

Notes: ① The tensile strength is not to exceed that required in the Table plus 150 N/mm².

② 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.

③ Special consideration may be given to alternative requirements, depending on design and application, and subject to agreement by CCS.

④ AT refers to ambient temperature of impact tests, i.e. 23±5℃.

~~6.2.4.3 The castings of primary hull structures (i.e. stem, stern frame, rudder bearing, propeller shaft bracket, rudder horn, stern tube shaft, castings for rudder blades, etc.) are to be subject to Charpy V-notch impact tests. The test specimens are to taken at t/4 from the surface of the sample. The test temperature is to be 0℃. The~~

~~impact energy is to be not less than 27 J.~~

6.2.4. ~~3~~4 For castings where the method of manufacture has been specially approved by CCS in accordance with 6.1.2.4, the number and position of test samples is to be agreed with CCS having regard to the method of manufacture employed.

Section 3 CASTINGS FOR MACHINERY CONSTRUCTION

6.3.1.1 The requirements of this Section apply to carbon ~~and,~~ carbon-manganese or alloy steel castings intended for use in machinery construction.

6.3.2.1 The chemical composition of ladle samples is to comply with the requirements of Table 6.3.2.1.

Chemical Composition of Castings for Machinery Construction Table 6.3.2.1

Steel type	Application	Chemical Composition (%)								
		C	Mn①	Si	P	S	Residual elements②			
							Cu	Cr	Ni	Mo
C, C-Mn	Castings for welded construction	≤0.23③	0.50~1.60	≤0.60	≤0.035	≤0.035	≤0.30	≤0.30	≤0.40	≤0.15
	Castings for non-welded construction	≤0.40	0.50~1.60	≤0.60	≤0.035	≤0.035	≤0.30	≤0.30	≤0.40	≤0.15
Alloy	Castings for welded construction	May be accepted according to recognized standards subject to agreement of CCS								
	Castings for non-welded construction	≤0.45	0.50~1.60	≤0.60	≤0.035	≤0.035	Alloying elements④			
							≤0.30	≤0.30	≤0.40	≤0.15

Note: ① The manganese content is not to be less than 3 times the actual carbon content.

② The total content of residual elements of C and C-Mn castings is not to be more than 0.80%.

③ If carbon equivalent C_{eq} calculated according to following formula is not more than 0.41%, the carbon content of castings may exceed the limit of 0.23%.

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

④ At least one of the elements is to comply with the minimum content.

6.3.3 Heat treatment

6.3.3.1 Castings are to be heat treated as follows:

(1) fully annealed; or

(2) normalized; or

(3) normalized and tempered at a temperature of not less than 550℃; or

(4) quenched and tempered.

6.3.3.2 Alloy castings are to be heat treated as follows:

(1) normalized; or

(2) normalized and tempered at a temperature of not less than 550℃; or

(3) quenched and tempered at a temperature of not less than 550℃.

6.3.3.~~2~~3 Engine bedplate castings, turbine castings and any other castings where dimensional stability and freedom from internal stresses are important are to be given a stress relief heat treatment as follows:

(1) the casting is to be heated to a temperature not lower than 550℃, followed by furnace cooling to 300℃ or lower; or

(2) fully annealed, and followed by furnace cooling to 300℃ or lower.

6.3.4.3 For carbon ~~or,~~ carbon-manganese or alloy steel castings, the mechanical properties are to comply with the requirements of Table 6.3.4.3.

Mechanical Properties of Castings intended for Welding for Machinery Construction Table 6.3.4.3(a)

Steel type	Tensile strength① ② R_m min. (N/mm²)	Yield strength R_{eH} min. (N/mm²)	Elongation A_5 min. (%)	Reduction of area Z min. (%)	Charpy V-notch impact minimum average energy③(J)	
					Temperature(℃)	Minimum average energy (J)
C, C-Mn	400	200	25	40	0	27
	440	220	22	30		
	480	240	20	27		
	520	260	18	25		
	560	300	15	20		
	600	320	13	20		
Alloy	550	355	18	30	0	27
	600	400	16	30		
	650	450	14	30		
	700	540	12	28		

Notes: ① The tensile strength may not exceed that required in the Table plus 150 N/mm².

② 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.

③ Special consideration may be given to alternative requirements, depending on design and application, and subject to agreement by CCS.

Mechanical Properties of Castings not intended for Welding for Machinery Construction Table 6.3.4.2(b)

Steel type	Tensile strength① ② R_m min. (N/mm²)	Yield strength R_{eH} min. (N/mm²)	Elongation A_5 min. (%)	Reduction of area Z min. (%)	Charpy V-notch impact minimum average energy③(J)	
					Temperature(℃)	Minimum average energy (J)
C, C-Mn	400	200	25	40	AT④	27
	440	220	22	30		
	480	240	20	27		
	520	260	18	25		
	560	300	15	20		
	600	320	13	20		
Alloy	550	340	16	35	AT④	27
	600	400	16	35		
	650	450	14	32		
	700	540	12	28		

Notes: ① The tensile strength may not exceed that required in the Table plus 150 N/mm².

② 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.

③ Special consideration may be given to alternative requirements, depending on design and application, and subject to agreement by CCS.

④ AT refers to ambient temperature of impact tests, i.e. 23±5℃.

Section 4 CASTINGS FOR CRANKSHAFTS

6.4.1.1 The requirements of this Section apply to carbon ~~and,~~ carbon-manganese or alloy steel castings for semi-built and fully built crankshafts. ~~For alloy steels, the tensile strength is not to exceed 700 N/mm^2.~~

6.4.5.3 For carbon ~~or,~~ carbon-manganese or alloy steel crankshaft castings, their mechanical properties are to comply with the requirements of Table 6.3.4.2 and 6.4.5.3.

~~**Mechanical Properties of Castings for Crankshafts** **Table 6.4.5.3**~~

~~Tensile strength① R_m min. (N/mm^2)~~	~~Yield strength② R_{eH} min. (N/mm^2)~~	~~Elongation② A_5 min. (%)~~	~~Reduction of area② Z min. (%)~~	~~Average energy for Charpy V-notch impact test min. (J)~~
~~400~~	~~200~~	~~28~~	~~45~~	~~32~~
~~440~~	~~220~~	~~26~~	~~45~~	~~28~~
~~480~~	~~240~~	~~24~~	~~40~~	~~25~~
~~520~~	~~260~~	~~22~~	~~40~~	~~20~~
~~550~~	~~275~~	~~20~~	~~35~~	~~18~~

~~Notes: ① For all grades of castings in the Table, the tensile strength range is 120 N/mm^2.~~
~~② 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.~~
~~③ Impact tests are to be carried out at an ambient temperature of 18℃ ~ 25℃.~~

Impact Properties of Castings for Crankshafts at Ambient Temperature **Table 6.4.5.3**

Tensile strength R_m min. (N/mm^2)	Charpy V-notch impact minimum average energy① (J) (J)
400	32
440	28

Note: Ambient temperature of impact tests is 23±5℃.

Section 5 STEEL CASTINGS FOR PROPELLERS

6.5.2.2 The chemical composition of ladle samples for castings for stainless steel propellers is to be in accordance with the requirements given in Table 6.5.2.2 of this Section. Cast steel the chemical composition of which deviates from the typical values of the Table below must be specially approved by CCS.

Chemical Composition of Castings for Carbon and Carbon-Manganese Steel Propellers

Table 6.5.2.2

Steel type	Alloy type①	Chemical composition (%)							
		C	Si	Mn	P	S	Ni	Cr	Mo②
1Cr12NiMo	M~~/F~~	≤ 0.15	≤ 1.5	≤ 2.0	≤ 0.035	≤ 0.030	≤ 2.0	11.5 ~ 17.0	≤ 0.5
0Cr13Ni4Mo	M~~/F~~	≤ 0.06	≤ 1.0	≤ 2.0	≤ 0.035	≤ 0.030	3.5 ~ 5.0	11.5 ~ 17.0	≤ 1.0
0Cr16Ni5Mo	M~~/F~~	≤ 0.06	≤ 1.5	≤ 2.0	≤ 0.035	≤ 0.030	3.5 ~ 6.0	15.0 ~ 17.5	≤ 1.5
1Cr18Ni12Mo	A	≤ 0.12	≤ 1.5	≤ 1.6	≤ 0.035	≤ 0.030	8.0 ~ 13.0	16.0 ~ 21.0	≤ 4.0

Notes: ① M – Martensitic; ~~F – Ferritic;~~ A – Austenitic.
② Minimum values are to be in accordance with international or national standards.

CHAPTER 7 IRON CASTINGS

Section 1 GENERAL PROVISIONS

7.1.1.1 This Chapter applies to ~~both~~ grey ~~and,~~ spheroidal or nodular graphite and alloy iron castings or other higher tensile strength iron castings intended for use in the construction of ships, machinery, boilers, pressure vessels and piping systems.

CHAPTER 9 OTHER NON-FERROUS MATERIALS

Section 1 COPPER ALLOY PROPELLERS

9.1.5.2
(1) Usually at least 1 mechanical test sample is to be taken from each ladle of liquid metal; ~~and the sample is usually to be cast towards the end of pouring process.~~
(2) If more than one castings are taken from one ladle of liquid metal, at least one mechanical test sample is to be taken from this ladle of liquid metal;
(3) If one or more castings are taken from two or more ladles of liquid metal, at least one mechanical test sample is to be taken from each ladle of liquid metal.
~~9.1.5.3 Where a batch of propellers made and heat treated from one cast with same shape and dimensions, at least one sample is to be provided for each multiple of five casings in the batch provided that the following conditions are met:~~
~~(1) integrally cast propeller with a diameter not greater than 1 m;~~
~~(2) for controllable pitch propeller, the weight of each blade or propeller hub not more than 200 kg.~~
9.1.5.34 Where propellers are subjected to a heat treatment, the test samples are to be heat treated together with them. The test sample material is to be removed from the casting by non-thermal procedures.
9.1.5.45 Round proportional tensile test specimens are to be cut from each test sample in accordance with the requirements given in Item 2 of Table 2.2.2.1 of this PART.
9.1.5.56 Where test specimens are to be taken from integrally cast test samples, this is to be the subject of special agreement with CCS. Wherever possible, the test samples are to be located on the blades in an area lying between 0.5 to 0.6 R, where R is the radius of the propeller. The test sample material must be removed from the casting by non thermal procedures.

CHAPTER 10 EQUIPMENT

Section 1 ANCHORS

10.1.4.3 The mass of anchors is to comply with following requirements:
(1) The mass of the head of an ordinary stockless anchor including pins and fittings is not to be less than 60% of the total mass of the anchor.
(2) The deviation of the actual mass of anchors from their nominal mass is to be within the range of +7% to -~~3~~7%.

Section 4 STEEL WIRE ROPES

10.4.4.3 Torsion test is to comply with the following requirements:
(1) 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.

(2) The wire is to be twisted by causing one or both of the vices to be revolved. A tensile load not exceeding 2% of the nominal breaking load of the wire may be applied to keep the wire stretched.
(3) The speed of the twisting is to comply with the recognized standards, and the number of complete twists is to meet the requirements of Table 10.4.4.3(3).

PART TWO NON-METALLIC MATERIALS

CHAPTER 3 FIBER-REINFORCED PLASTIC HULL MATERIALS

Section 3 LAMINATING PROCEDURE

3.3.12 Secondary bonds

3.3.12.1 Secondary bonding is the application of a wet resin ply to an already fully cured surface. In general, secondary bonds are only to be used when an integral moulding cannot be achieved or internal members are to be bonded to the hull or, repairs are to be carried out.

3.3.12.2 Laminating is to proceed as a continuous process, as far as practicable, with the minimum of delay between successive plies. Where a secondary bond is to be made, it is to be carried out in accordance with the resin manufacturer's recommendations, details of which are to be incorporated in the quality control documentation.

3.3.12.3 When preparing for a secondary bond, the following principles are to be followed so far as possible:
(1) The area is to be clean and free from all foreign particles such as wax, grease, dirt and dust.
(2) When grinding is required (especially in highly stressed areas), this is not to damage glass fibers of any structure or reduce the thickness of the laminate.
(3) The first ply during the secondary lay-up is to be chopped strand mat.
(4) The area, which has been lightly abraded or a peel ply of which has been removed, is to be wiped with a suitable solvent and allowed to dry prior to laminating.

3.3.14 Bonding laminates with adhesives

3.3.14.1 Bonding laminates with adhesives is a procedure in which laminates are connected by structural adhesives.

3.3.14.2 Procedures for bonding by adhesives for load-bearing parts are to be submitted to CCS for approval and evidence that the strength of the bonding joints meets the design requirements is to be submitted (e.g. historical test records of the same adhesive and the same procedure). If a new adhesive or a new procedure is used, the strength of the bonding joint is to be verified by test to confirm that its strength and other properties meet the design requirements.

3.3.14.3 The adhesives are to be compatible with the resin used at the position to be bonded. The adhesives may not have any negative effects on the materials to be joined.

3.3.14.4 If FRP components are to be bonded and a resin adhesive system differing from the laminating system is used, the components are to be totally cured before bonding.

3.3.14.5 The surfaces of the materials to be bonded together are to be dry and free of release agents (wax, grease, oil etc.), impurities (dust, rust, etc.) and solvents.

3.3.14.6 Smooth surfaces are to be roughened mechanically (rough-grinding, sand-blasting etc.). Any layers on the surface of the materials to be bonded, that may exert a negative effect on the bonding process (e.g. skin-forming additives in polyester resins or residues of peel ply in the case of FRP) are to be removed.

3.3.14.7 The adhesive is to be processed in accordance with the manufacturer's instructions; the proportion of fillers are not to exceed the permitted limit. When mixing the adhesive, its constituents are to be mixed in such a way that they are evenly distributed, care being taken to beat in as little air as possible.

3.3.14.8 The environmental conditions for applying the adhesives are to meet the requirements of the adhesive manufacturer.

3.3.14.9 The adhesive is to be applied evenly and as bubble-free as possible to the materials to be joined. If highly thixotropic adhesives are used, it is advisable to apply a thin undercoat of the corresponding pure

resin to the surfaces to be joined in accordance with the procedures recommended by the adhesive supplier.
3.3.14.10 Following application of the adhesive, the materials to be joined are to be brought together without delay and fixed in place.
3.3.14.11 A loading of the adhesive joint is not to take place before the adhesive has cured sufficiently. For all adhesive joints with thermosetting adhesives, subsequent tempering of the joint is recommended.
3.3.14.12 After curing, the adhesive joint is to be protected by suitable means against penetration by extraneous media (e.g. moisture).

CHAPTER 7 FIBER ROPES

Section 2 FIBER ROPES FOR OFFSHORE MOORING

7.2.5 Inspection of fiber rope

7.2.5.1 For completed fiber rope product for offshore mooring, external visual inspection is to be carried out to verify compliance of rope structure with design and check the evenness of lay-up.

7.2.5.2 ~~One sample is to be taken from each coil of fiber rope product to examine~~ Fiber rope product is to be examined for linear density, wet breaking load and nominal diameter.

PART THREE WELDING

CHAPTER 2 WELDING CONSUMABLES

Section 4 WIRE-FLUX COMBINATIONS FOR SUBMERGED ARC AUTOMATIC WELDING

2.4.2 Tests

2.4.2.5 Where welding consumables are intended to be used for high strength steel used for welding structures with a yield strength of 420 N/mm^2 and above, a hydrogen test is to be carried out in accordance with 2.3.6 of Section 3 of this Chapter ~~the method approved by CCS~~, and the test results are to comply with the requirements of Table 2.3.1.1 in Section 3 of this Chapter.

Section 5 WIRES AND WIRE-GAS COMBINATIONS FOR SEMI-AUTOMATIC AND AUTOMATIC WELDING

2.5.1 General requirements

2.5.1.2 Flux-cored wires are to be subjected to the deposited metal hydrogen test in accordance with 2.3.6 of Section 3 of this Chapter ~~with the method approved by CCS~~, and the test results are to satisfy the requirements of Table 2.3.6.3 of this Chapter. An appropriate low hydrogen suffix will be added after the grade mark of welding consumables which have satisfied low hydrogen requirements. The low hydrogen requirements for different grades of welding consumables are given in Table 2.3.1.1 of this Chapter.

2.5.1.3 The composition of the shielding gas used in the approval test is to be reported, and the group and composition limits of shield gas are given in Table 2.5.1.3. When a wire is used in composition with grouped shielding gases, they are to be subjected to an approval test respectively.

Compositional Limits of Designated Groups of Gas Types and Mixtures Table 2.5.1.3

Group	Gas composition (Vol. %)			
	Argon (Ar)	Carbon dioxide (CO_2)	Oxygen (O_2)	Hydrogen (H_2)
I1	100	-	-	-
M11	Residual[①②]	~~0~5~~ $0<CO_2\leq5$	–	~~0~5~~ $0<H_2\leq5$
M12	Residual[①②]	~~0~5~~ $0<CO_2\leq5$	–	–
M13	Residual[①②]	–	~~0~3~~ $0<O_2\leq3$	–
M14	Residual[①②]	~~0~5~~ $0<CO_2\leq5$	~~0~3~~ $0<O_2\leq3$	–
M21	Residual[①②]	~~5~25~~ $5<CO_2\leq25$	–	–
M22	Residual[①②]	–	~~3~10~~ $3<O_2\leq10$	–
M23	Residual[①②]	~~5~25~~ $5<CO_2\leq25$	~~0~8~~ $0<O_2\leq8$	–
M31	Residual[①②]	~~25~50~~ $25<CO_2\leq50$	–	–
M32	Residual[①②]	–	~~10~15~~ $10<O_2\leq15$	–
M33	Residual[①②]	~~5~50~~ $5<CO_2\leq50$	~~8~15~~ $8<O_2\leq15$	–
C1	–	100	–	–
C2	–	Residual	~~0~30~~ $0<O_2\leq30$	–

Notes: ① 95% of the content of argon gas may be substituted by helium gas.
② The content of helium gas used is to be greater than or equal to that of argon gas.

CHAPTER 3 APPROVAL OF WELDING PROCEDURES

Section 1 GENERAL PROVISIONS

3.1.3 Approval

3.1.3.1 It is the shipbuilder's or manufacturer's responsibility to establish and document whether a welding procedure specification is suitable for the particular application. Prior to the commencement of construction, the shipbuilder or manufacturer is to prepare a summary table of welding procedures in combination with their own technical conditions and production experiences and submit it to the Surveyor for approval. The name and number of the welding procedure specification intended for use are to be indicated in the summary table according to different positions, types and sizes of welds at structures and connections.

Section 3 WELDING PROCEDURE APPROVAL TESTS FOR FILLET WELDS

3.3.4 Test results

3.3.4.3 The results from the hardness test of steel structures are given in Table 3.2.5.6, Section 2 of this Chapter. The results from the hardness test of duplex stainless steel and lean duplex stainless steel are given in 3.2.7.2 of Section 2 of this Chapter.

CHAPTER 4 QUALIFICATION TESTS OF WELDERS

Section 1 GENERAL PROVISIONS

4.1.4 Categorization of qualification test items

4.1.4.3 For welders engaged in the welding of marine boilers and pressure vessels, special tests of ~~tube~~ pipe-to-plate ~~fillet~~ welding of insertion type are to be carried out when necessary.

4.1.7 Validity of the qualification

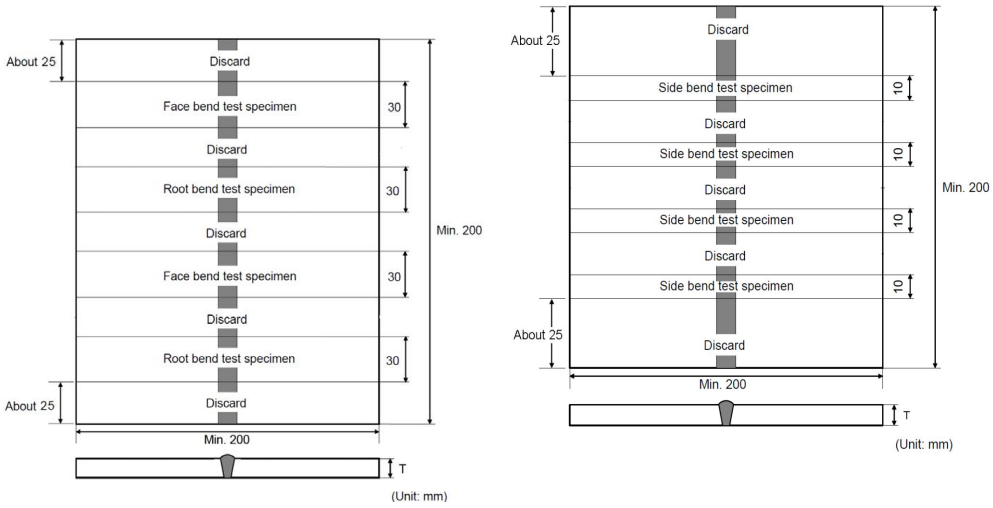
4.1.7.3 If any of these conditions is not fulfilled, CCS is to be informed and the certificate is to be cancelled. The validity of the certificate may be maintained in agreement with CCS if the maintenance scheme of

qualification is in accordance with either one of 4.1.7.4 and the maintenance option selected is to be indicated in the certificate issued. Even if the requirements stipulated in the standards are applied, the requirement for revalidation of welders' qualification is to be in accordance with 4.1.7.4.

Section 2 QUALIFICATION TESTS AND EVALUATION OF WELDERS

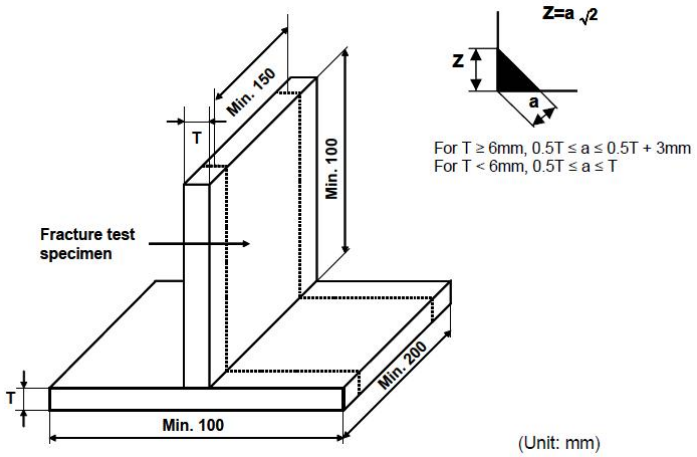
4.2.2 Type and dimensions of test assemblies

4.2.2.1 Dimensions for butt and fillet welds in plates, butt welds in pipes and pipe-to-plate fillet welds are shown in Figures 4.2.2.1(a), (b), (c) and (d) respectively.

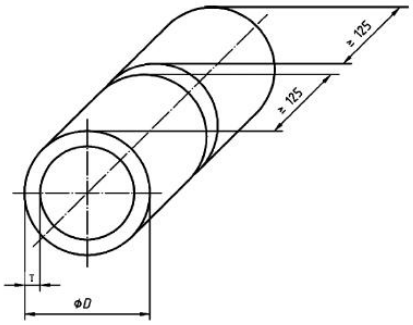


T<12 mm T≥12 mm

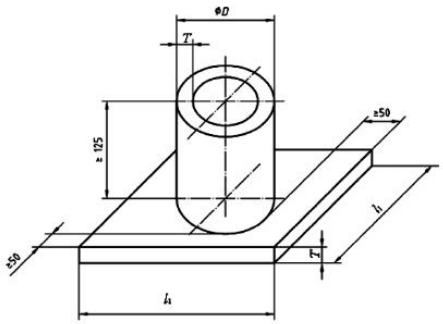
(a) Butt welds in plates



(b) Fillet welds in plates



(c) Butt welds in pipes



(d) Pipe-to-plate fillet welds ~~(insertion)~~

(in mm)

Figure 4.2.2.1 Dimensions of Test Assemblies

4.2.2.5 ~~Insertion is to be adopted for pipe-to-plate fillet welds, and the type of joint~~ The joint for pipe-to-plate welds of insertion type is shown in Figure 4.2.2.5.

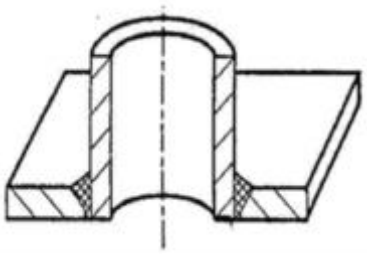


Figure 4.2.2.5 Pipe-to-plate ~~fillet~~ welds of insertion type

Section 3 SCOPE OF APPLICATION OF WELDER'S QUALIFICATION

4.3.3 Types of welds

~~4.3.3.3 Butt welds in pipes greater than 25 mm in outside diameter cover butt welds in plates for appropriate welding positions.~~

~~4.3.3.4 Butt welds in plates cover butt welds in pipes of not less than 600 mm in outside diameter for appropriate welding positions and pipes of not less than 150 mm in outside diameter for the horizontally rolling welding position.~~

4.3.7 Welding positions

4.3.7.1 The welding positions qualified as a result of the actual welding position used in a satisfactory welder's qualification test, are shown in Tables 4.3.7.1a, 4.3.7.1b ~~and,~~ 4.3.7.1c and 4.3.7.1d (Diagrams showing the definitions of weld position used in these Tables are shown in Figure 4.3.7.1 and Table 4.3.7.1 ~~de~~).

A qualification test with fillet welding may be required for welders who are employed to perform fillet welding only. Welders engaged in welding of T joints / pipe-to-plate fillet welding with partial or full penetration are to be qualified for butt welding.

Qualified welding positions when testing with butt welding of plates Table 4.3.7.1a

Qualification Test Position with butt weld of plates	Qualified welding positions in actual welding works①	
	Butt welds	Fillet welds
F	F	FF, FH
H	F, H	FF, FH, FHa
Vu	F, Vu	FF, FH, FVu
Vd	Vd	FVd
O	F, H, O	FF, FH, FHa, FO, FOa

Note: ① Butt welding of plates can cover butt welding of pipes and pipe-to-plate fillet welding with an outer diameter of not less than 600mm at corresponding positions, and butt welding of pipes with an outer diameter of not less than 150mm at the

horizontally rolling welding position, subject to the agreement of CCS.

Qualified welding positions when testing with fillet welding of plates Table 4.3.7.1b

Qualification Test Position with plate fillet weld	Qualified plate fillet welding positions in actual welding works①
FF	FF
FH	FF, FH
FHa	FF, FH, FHa
FVd	FVd
FVu	FF, FH, FVu
FO	FF, FH, FHa, FO, FOa
FOa	FF, FH, FHa, FO, FOa

Note: ① Fillet welding of plates can cover pipe-to-plate fillet welding with an outer diameter of not less than 600mm at the corresponding positions, subject to the agreement of CCS.

Qualified welding positions when testing with butt welding of pipes Table 4.3.7.1c

Qualification Test Position with butt weld of pipes	Qualified welding positions in actual welding works			
	Butt welding of plates①	Butt welding of pipes	Fillet welding of plates①	Pipe-to-plate fillet welding②
1G	F	1G	FF、FH	--1FG
2G	F、H	1G、2G	FF、FH、FHa	1FG, 2FG
5G	F、Vu、O	1G、5G	FF、FH、FVu、FO、FOa	1FG, 2FG、4FG、5FG
2G+5G	F、H、Vu、O	1G、2G、5G、6G	FF、FH、FHa、FVu、FO、FOa	1FG, 2FG、4FG、5FG、6FG
6G	F、H、Vu、O	1G、2G、5G、6G	FF、FH、FHa、FVu、FO、FOa	1FG, 2FG、4FG、5FG、6FG
6GR③	F、H、Vu、O	1G、2G、5G、6G	FF、FH、FHa、FVu、FO、FOa	1FG, 2FG、4FG、5FG、6FG

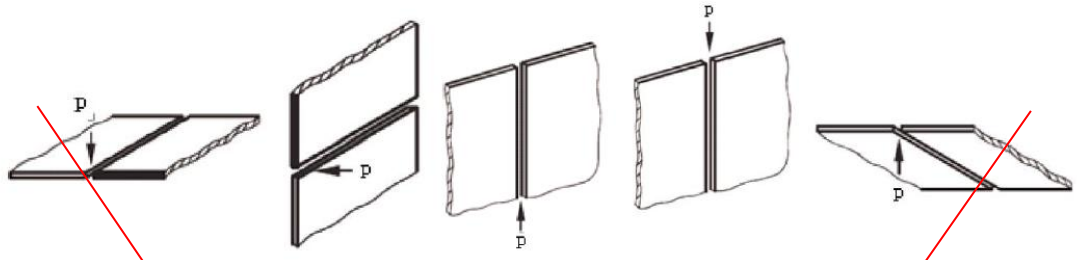
Notes： ① Butt weld joints of pipes with an external diameter more than 25 mm only apply to butt weld joint of plates at corresponding position.

② Not applicable to special pipe-to-plate fillet welds (insertion) in boilers and pressure vessels.

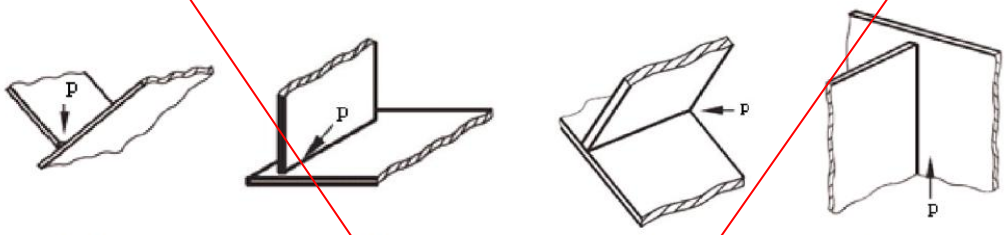
③ 6GR welding position is to be used for full penetration inclined or T-shaped pipe joints.

Qualified welding positions when testing with pipe-to-plate fillet welding Table 4.3.7.1d

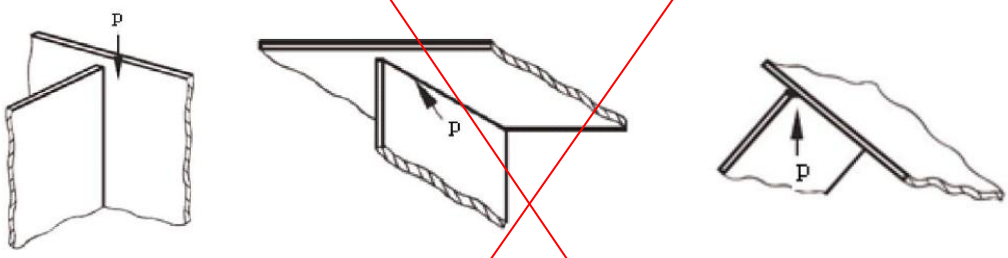
Qualification Test Position with pipe-to-plate fillet weld	Qualified fillet welding positions in actual welding works	
	Pipe-to-plate fillet welding	Fillet welding of plates
1FG	1FG	FF
2FG	1FG, 2FG	FF, FH
4FG	1FG, 2FG, 4FG	FF, FH, FHa, FO, FOa
5FG	1FG, 2FG, 4FG, 5FG	FF, FH, FHa, FVu, FO, FOa
6FG	1FG, 2FG, 4FG, 5FG, 6FG	FF, FH, FHa, FVu, FO, FOa
4FG+5FG	1FG, 2FG, 4FG, 5FG, 6FG	FF, FH, FHa, FVu, FO, FOa



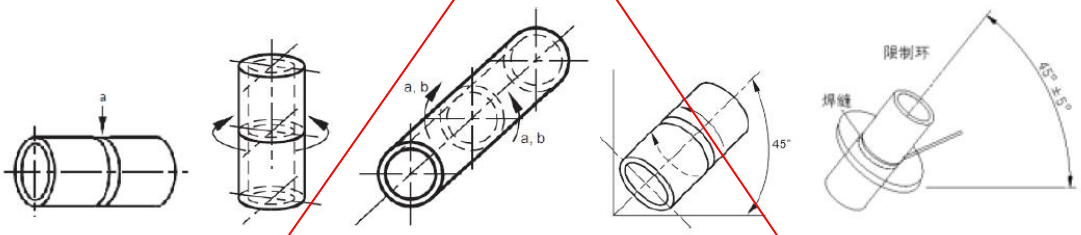
F（PA） H（PC） Vu（PF） Vd（PG） O（PE）



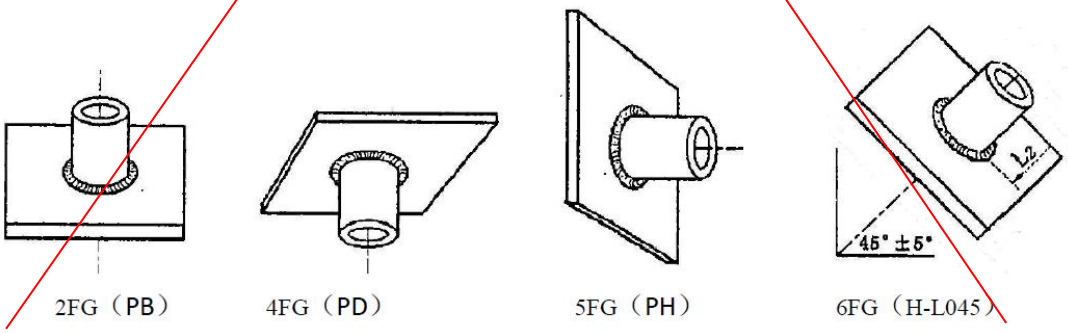
FF（PA） FH（PB） FHa（PC） FVu（PF）



FVd（PG） FO（PD） FOa（PE）



1G（PA） 2G（PC） 5G（PH） 6G（H-L045） 6GR



2FG（PB） 4FG（PD） 5FG（PH） 6FG（H-L045）

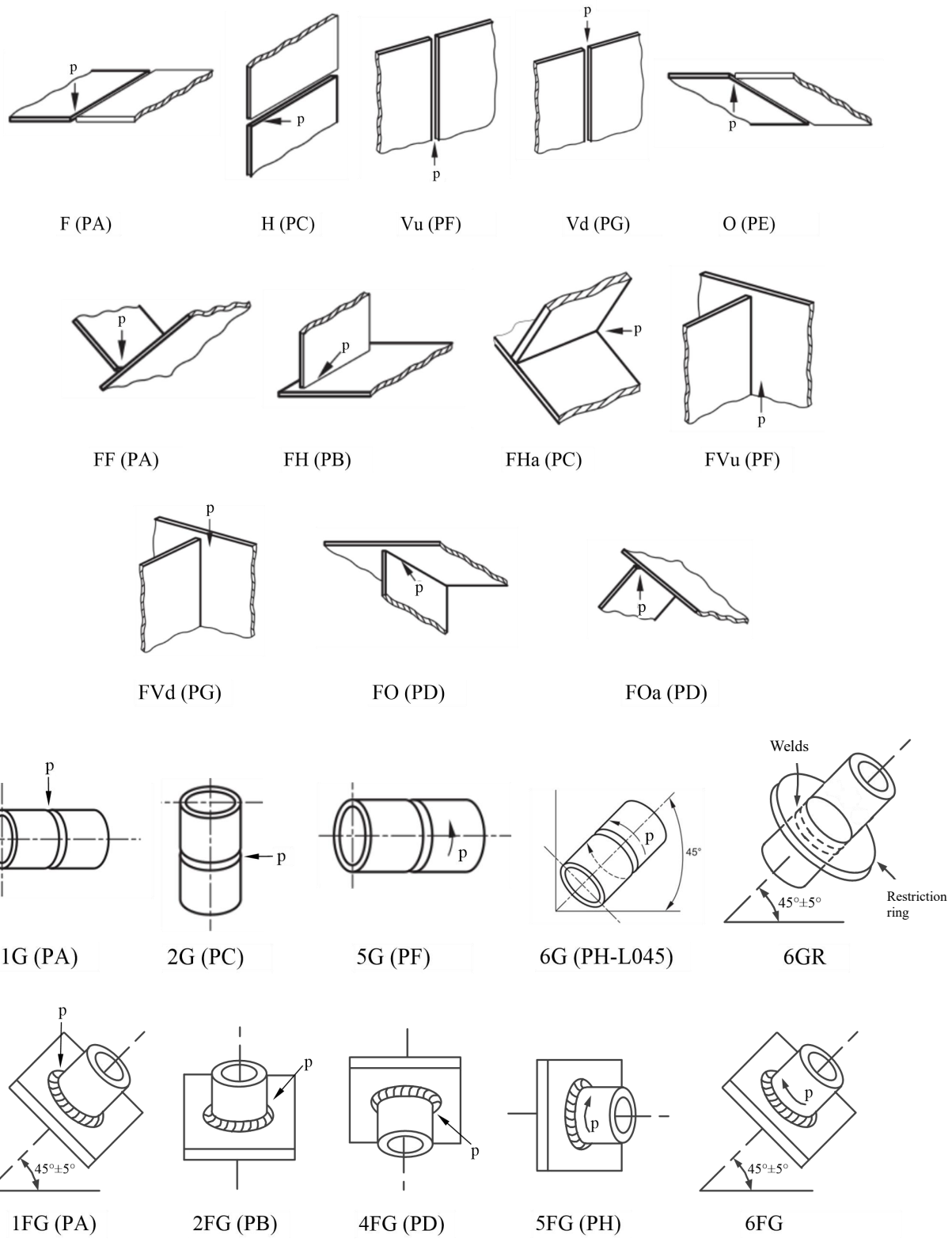


Figure 4.3.7.1 Welding Positions

Code of Welding Positions **Table4.3.7.1-~~d~~c**

Type of assembly	Code of welding position	Welding positions	ISO6947 corresponding code
Butt welding of plates	F	Flat (downhand) welding	PA
	Vu	Vertical upwards welding	PF

Type of assembly	Code of welding position	Welding positions	ISO6947 corresponding code
	Vd	Vertical downwards welding	PG
	H	Horizontal welding	PC
	O	Overhead welding	PE
Butt welding of pipes	1G	Welding of horizontally rolling pipes	PA
	2G	Welding of vertically fixed pipes	PC
	5G	Welding of horizontally fixed pipes	PH
	6G	Welding of pipes fixed at 45° inclination	PH-L045
	6GR	Welding of pipes fixed at 45° inclination with restriction ring	-
Fillet welding of plates	FF	Fillet welding in the flat position	PA
	FH	Fillet flat welding	PB
	FHa	Fillet horizontal welding	PC
	FVu	Fillet vertical upwards welding	PF
	FVd	Fillet vertical downwards welding	PG
	FO	Fillet overhead welding	PD
	FOa	Fillet overhead welding	PE
Pipe-to-plate fillet welding	1FG	Welding of rolling pipes at 45° inclination	PA
	2FG	Fillet horizontal welding of vertically fixed pipe	PB
	4FG	Fillet overhead welding of vertically fixed pipe	PD
	5FG	Fillet welding of horizontally fixed pipe	PH
	6FG	Fillet welding of pipe fixed at 45° inclination	~~H-L045~~ -

CHAPTER 5 WELDING OF HULL STRUCTURES

Section 1 GENERAL PROVISIONS

5.1.4 Selection of welding consumables

5.1.4.2 For the joining of steels of different strength levels, the welding consumables in general may be of a type suitable for the lower strength level ~~except at structural discontinuities or areas of stress concentration~~. For the joining of steels of the same strength level but of different toughness grades, the welding consumables in general may be of a type suitable for the lower toughness grade except for the structural members subjected to complicated forces or severe construction conditions.

Section 3 INSPECTION AND REPAIRING OF WELDS

5.3.2 Inspection

5.3.2.4 The number (n) of non-destructive testing points in the strength deck and shell within 0.6L amidships (except where enhanced testing is required in 5.3.2.6) may be calculated by the following formula:

$$n = 0.16k\ (i + 0.1W_T) + 0.04W_L$$

where: n — the number of non-destructive testing points within 0.6L amidships;

k — average breadth of plates within 0.6L amidships, in m, which may be obtained from the following formula:

$$k = \frac{\text{circumference at transverse midship section (excluding opening)}}{\text{number of strakes seen at transverse section}};$$

i — amount of intersections of butt welds within 0.6L amidships;

W_T — whole length of transverse welds within 0.6L amidships, in m;

W_L — whole length of longitudinal welds joining the blocks within 0.6L amidships (length of all longitudinal butt welds within 0.6L amidships for ships without longitudinal butt welds joining the blocks), in m.

L is the distance on the summer load waterline from the forward side of the stem to the after side of the rudder post, or to the center of the rudder stock if there is no rudder post. L is not to be less than 96%, and need not be greater than 97%, of the extreme length on the summer load waterline. For pontoon hulls, L is the distance on the summer load waterline from the forward side of the fore end plate to the after side of the after end plate. For ships without rudder stocks, L is 97% of the extreme length on the summer load waterline.

The density of non-destructive testing points is to be decreased in number with the decrease of structure importance and stress.

Where non-destructive testing is carried out at an intersection, the direction of testing is to be paralleled to the direction of the transverse welds.

Testing points are generally to be tested by radiographic method. Ultrasonic tests may also be used subject to the agreement of CCS. The length of ultrasonic testing point is 500 mm.

5.3.2.5 The number of testing points ~~radiographs~~ for the welds in the strength deck and shell outside 0.6L amidships is to be about 10% to 20% of that specified in 5.3.2.4~~, and ultrasonic tests of a suitable number may be allowed~~.

The number of tests in critical areas (such as shaft wrapper plates, stem and stern frame areas, bow wave impact areas and area strengthened for ice) is to be greater than that in other areas.

5.3.2.6 The welds in the following essential areas of hull structures are to be subject to non-destructive testing by radiographic or ultrasonic method (unless otherwise specified) according to the ~~following~~ requirements:

(1) For intersection of butt welds on tank watertight bulkhead, inner bottom plate and hopper tank sloping plate, one in four.

(2) For butt connections of longitudinals and girders at bottom, side and deck,

within 0.4L amidships — one in ten;

outside 0.4L amidships — one in twenty.

(3) For butt welds at insert plate boundary of strength deck hatch corner, at least 2 non-destructive testing at each corner, as shown in Figure 5.3.2.6(3).

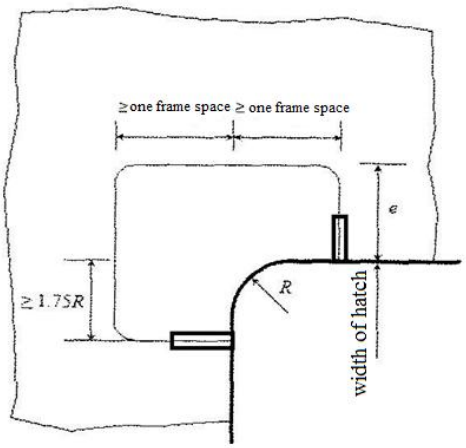


Figure 5.3.2.6(3)

(4) For butt connections 50 mm and above in thickness (such as stern frames, shaft brackets, stabilizer recesses, masts and deck stringers), 100% non-destructive testing.

(5) When full-penetration fillet welds are used at following positions, non-destructive testing is to be carried out according to the following requirements:

a. connection of main engine foundation girders to top plate: 100%;

b. rudder horn and shaft bracket to shell plate of hull structure: 100%;

c. connection of rudder side plating to cast rudder stock: 100%;

d. edge reinforcement or pipe penetration both to strength deck, sheer strake and bottom plating within 0.6L amidships, when the dimensions of the opening exceeds 300 mm: 100%;

e. toe connections of longitudinal hatch coaming end bracket to the deck plating: within 0.6L amidships: 100%; outside 0.6L amidships—one in two;

f. connection of inner bottom with transverse bulkheads, bottom girder with inner bottom plating, lower

stools or transverse floors, or connection of lower stools with transverse bulkheads: 35%;

g. connection of hopper tank sloping plates with inner bottom or inner side: 25%;

h. connection of transverse corrugated bulkheads with topside tanks: 35%;

i. deck stringer/sheer strake joint: 10%, and within 0.6*L* amidships: 1 m increase for the testing at each erection weld.

(6) In addition, the following positions are to be subject to surface crack examination:

a. Welds including ~~of~~ steel castings and steel forgings as well as welds welded under stress or low temperature are to be subject to 100% surface crack examination;

b. Welds of essential positions with plate thickness of 30 mm or above (e.g. welds on stern frames, welded mast and bulkhead stool, etc.) are to be subject to 100% surface crack examination;

c. ~~Welds in high stress areas are to be subject to 100% surface crack examination.~~

~~d.~~ Other welds with edge preparation thickness at 30 mm or above are to be subject to 20% surface crack examination as a minimum.

5.3.2.7 Following locations are to be sampled for non-destructive testing:

(1) restart/stop points of automatic butt welds (electro slag, electro gas, submerged arc welding);

(2) butt connections of bilge keel;

(3) butt welds on inner hull and watertight bulkhead of oil tanker;

(4) butt welds on longitudinal continuous hatch coaming and top plate of container ship;

(5) butt connection of longitudinal continuous hatch coaming (including the top plate) more than 0.15*L* in length, of ships other than container ships;

(6) butt welds at structure change near superstructure;

(7) welds of critical locations determined by direct calculation of structural strength or fatigue strength evaluation;

(8) full penetration welds which are inaccessible or very difficult to inspect in service (such as welds at inner sharp angle within bulb bow of ship);

(9) other strength welds which are deemed important, subject to high stress or may have significant impact after failure.

CHAPTER 6 WELDING OF OFFSHORE STRUCTURES

Section 1 GENERAL PROVISIONS

6.1.1 Application

6.1.1.1 This Chapter applies to the welding and inspection of mobile, floating and fixed offshore steel structures.

Section 2 WELDING OF STRUCTURES

6.2.6 Welding of very thick members (t > 50 mm) and for joining of pipes

6.2.6.1 The welding of very thick members and pipes is to be carried out using low hydrogen ~~electrodes~~ welding consumables and proper welding procedures and full penetration is to be ensured.

Section 3 INSPECTION OF WELDS

6.3.2 Supplementary requirements for fixed offshore structures

6.3.2.1 Visual inspection

(1) Profiles of welds are to comply with design drawings and the following requirements:

① the reinforcement of butt welds is to comply with the relevant criteria and not to exceed 3 mm;

② for fillet welds, the length difference between two legs is not to exceed 2 mm and buildup R is not to exceed the value calculated by the following formula:

$$R = 0.1K + 0.76 \quad \text{mm}$$

where: K – leg length of fillet welds;

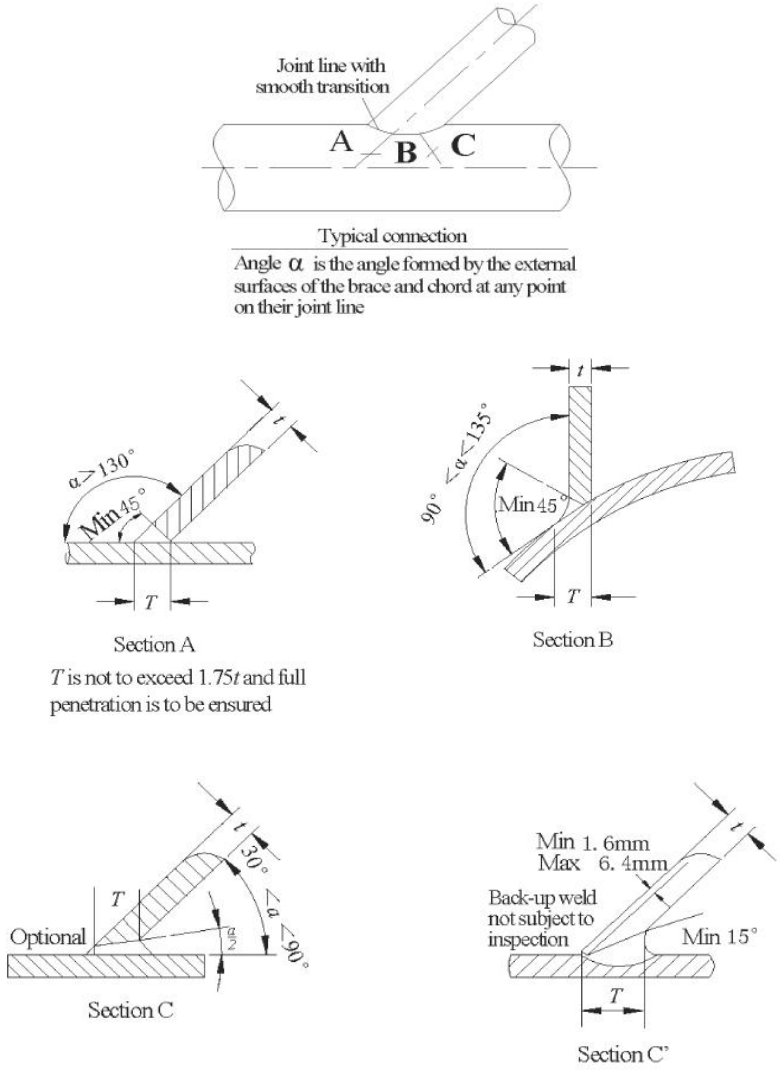
③ weld dimensions of pipe joints are to be as shown in Figure 6.3.2.1(1)①, ② and Table 6.3.2.1(1). The

profile after grinding is to comply with the relevant requirements of the design and construction;

④ all laps of tight welds are to be of continuous fillet welds, of which the leg length is usually not to exceed 5 mm, unless stated otherwise.

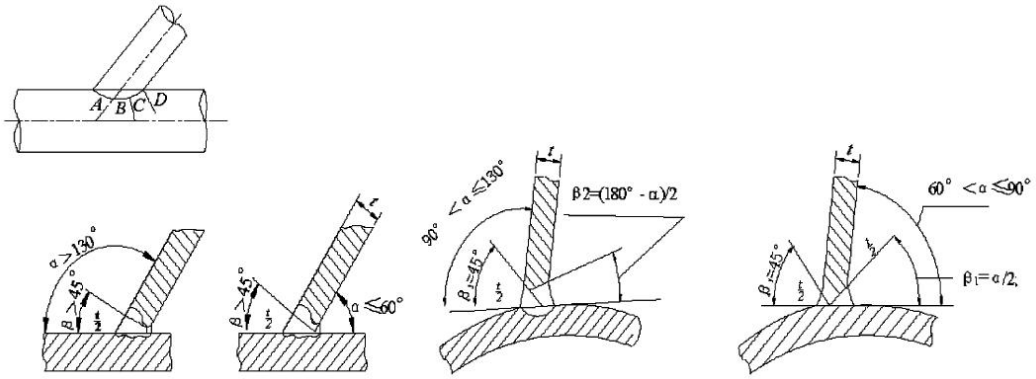
***α* and *T* for Typical Connection** **Table 6.3.2.1(1)**

α	T
$\leq 35°$	$1.75t$
$35° < \alpha \leq 50°$	$1.50t$
$50° < \alpha \leq 135°$	$1.25t$
$> 135°$	See section A



The thickness "*T*" does not include the concave due to the smooth transition from the weld to the base metal

Figure 6.3.2.1(1)①



Section *A* Section *D* Section *B* Section *C*

Figure 6.3.2.1(1)②

(2) The undercut depth is not to exceed 0.25 mm for primary members and 0.6 mm for secondary members.

(3) All surface defects are to be completely repaired prior to non-destructive and tightness tests. Repairing procedures are to comply with the relevant requirements in 6.2.8 of this Chapter.

6.3.2.2 Non-destructive testing of welds

(1) The non-destructive testing for butt welds is specified as follows:

① for the welds of special members or the welds connecting special and primary members, 100% ultrasonic inspection is to be performed. Additionally according to service conditions and plate thicknesses etc., 10% ~ 20% radiographic inspection and 20% ~ 100% magnetic particle inspection are to be carried out. The extent for radiographic and magnetic particle inspections of welds is to be agreed by CCS;

② for the welds of primary members or the welds connecting primary and secondary members, 10% ~ 20% ultrasonic inspection and 10% ~ 20% magnetic particle inspection are to be performed. The extent for such inspections is to be agreed by CCS. Where there is any doubt about the results of ultrasonic inspection of welds, additional radiographic inspection is to be made;

③ for the welds of secondary members, 0% ~ 5% ultrasonic inspection and 0% ~ 5%magnetic particle inspection are to be performed. The extent for such inspections is to be agreed by CCS;

④ for (T-shaped or cruciform) intersections of primary butt welds, radiographic inspection is to be performed.

(2) Non-destructive testing for full-penetration fillet welds is specified as follows:

① for the welds of special members and the welds connecting primary and secondary members, 100% ultrasonic inspection and 100% magnetic particle inspection are to be performed. A certain extent of radiographic inspection may be required by CCS according to actual conditions;

② for the welds of primary members and the welds connecting primary and secondary members, 20% ultrasonic inspection and 20% ~ 100% magnetic particle inspection are to be performed. The extent of magnetic particle inspection is to be agreed by CCS;

③ for the welds of secondary members, 0% ~ 5% ultrasonic inspection and 0% ~ 5% magnetic particle inspection are to be performed. The extent for such inspections is to be agreed by CCS.

(3) For the welds of pipe joints, 100% ultrasonic inspection and 100% magnetic particle inspection are to be carried out. A certain extent for radiographic inspection may be required by CCS.

(4) Radiographic inspection:

① Positions of such inspection and radiographs required may be proposed by the builder according to the categories, types, service conditions of structural members and the requirements of 6.3.2.2, subject to agreement of CCS.

② The radiographic sensitivity is to comply with the following requirements:

(a) in the radiograph, image quality indicators (IQI) of the wire type are to be placed on the side of the radioactive source. In case the source side is inaccessible, they may also be placed on the film side after determining the effects on the penetrating sensitivity provided that compliance of the actual sensitivity with the specified requirements is ensured by contrast tests. If one exposure technique is used to cover the whole pipe girth weld, at least 3 equally spaced image quality indicators are to be placed around the girth;

(b) the penetrating sensitivity (*S*) of the IQI placed on the source side is to be determined by the

following formula:

$$S = \frac{d \times 100}{t}\%$$

where: d – diameter of the thinnest visible wire, in mm;
t – thickness of the weld, in mm.

The sensitivity obtained by the above formula is to comply with the requirements in Figure 6.3.2.2(4)②.

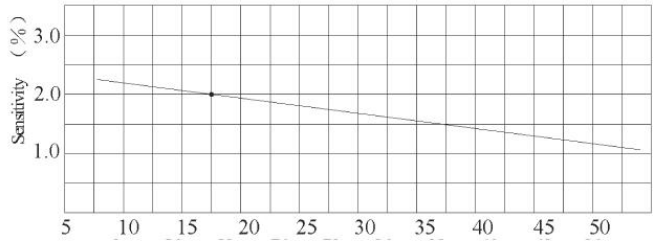


Figure 6.3.2.2(4)②

③ Items such as name of inspector, no. of the weld, date of radiographing, penetrating sensitivity, weld length radiographed, shape/size/nature of defects are to be indicated in the inspection report. The weld quality is to be evaluated according to the requirements in 6.3.2.2(6), and positions to be repaired are to be proposed. All the films of radiographic inspection together with the report are to be kept on file for reference.

(5) Ultrasonic inspection:

① For full-penetration fillet welds and pipe joints due to which structural members are subjected to tensional stresses in the through thickness direction, ultrasonic inspection is to be carried out within an area of 100 mm in width along the weld to examine whether there is lamellar tearing.

② The builder is to prepare inspection procedures for specific structures beforehand, calibrate the ultrasonoscope and determine the initial sensitivity. If abnormal test results are obtained or the ulstrasonoscope is damaged during inspection, re-calibration and re-test are to be carried out.

③ Calibration of the ultrasonoscope is to be performed on test pieces having simulated defects or contrast blocks with a drilled hole. The simulated test pieces or contrast blocks are usually to be made of the same material as the structural members. Where the sizes of defects are evaluated by calibrating amplitudes, the effects of sound beam attenuation, surface roughness and curvature, etc. are to be taken into consideration.

④ For unqualified and nearly unqualified welds, the following data are to be listed and shown schematically in the ultrasonic inspection report:
(a) positions and length of defects along the center line of welds;
(b) positions and size (width) of defects in the cross section of welds;
(c) estimated defect types.

Welding quality is to be evaluated and the extent of repairs proposed according to the requirements in 6.3.2.2(6).

(6) Acceptance criteria for internal quality of welds:

① The internal quality of welds of fixed offshore structures is to comply with the requirements shown in Table 6.3.2.2(6)①. Where other criteria are to be used, they are to be agreed by CCS.

② Weld defects exceeding the limits of acceptance criteria, which are proved harmless to the safety of the structure by results of fracture toughness tests or comprehensive information related, may be exempted from repairs, subject to agreement of CCS.

Criteria for Internal Quality of Welds **Table 6.3.2.2(6)①**

Type of defects \ Category of members	Special and primary members	Secondary members
Cracks	Not allowed	Not allowed
Lack of fusion	Not allowed	Not allowed

Incomplete penetration		Not allowed	Not allowed
Slag inclusion	Bar slag (length)	≤ t/2	≤ 2t/3
	Spot slag (size of each point)	≤ t/4	≤ t/3
Pore	Tubular pore (length)	≤ t/2	≤ 2t/3
	Scattered spot pores (size of each point)	≤ t/4	≤ t/3
	Sum of diameters of clustered pores	≤ t/2	≤ 2t/3
Sum of lengths of all defects within the range of any weld of 6t in length		≤ 3t/4	≤ t
The minimum space between defects greater than 2.4 mm		≥ 2.2t	≥ 2t

Notes: ① Bar slag inclusions or tubular pores refer to the defects of which the aspect ratio exceeds 3. Those defects of which the aspect ratio does not exceed 3 refer to spot slag inclusions or scattered spot pores.
② t is the effective throat thickness for fillet welds and the plate thickness for butt welds, in mm.
③ The maximum size of spot slag inclusions or scattered spot pores is 4 mm for t ≤ 51 mm and 6 mm for t > 51 mm.

CHAPTER 8 WELDING OF IMPORTANT MACHINERY COMPONENTS

Section 4 NON-DESTRUCTIVE INSPECTION AND WELD REPAIRS OF PROPELLERS

8.4.5 Welding repair procedure

8.4.5.3 The use of any welding procedure without prior approval is subject to a satisfactory approval test witnessed by the Surveyor (detailed test requirements are given in Table 8.4.5.3(1) and Figure 8.4.5.3(1), Figure8.4.5.3(2). The test is to be carried out with the base metal, welding process, filler metal, preheating and stress-relieving treatment as those covered in Table 8.4.5.3(2). A qualification of a WPS obtained by a manufacturer is valid for welding in workshops or sites under the same technical and quality control of that manufacturer. ~~All weld repairs are to be carried out in accordance with the procedure specification qualified at valid workshops under the same technical and quality management.~~ Welding Procedure Qualification Tests are to be signed by the CCS Surveyor witnessing the tests. Such welding procedure can only be used in weld repair of propellers after satisfactory testing. All weld repairs are to be made by certified welders strictly in accordance with approved procedures. Welder examination is to comply with recognized standards.

Propeller repair welding procedure qualification test requirements ~~**Test requirements for approval of repair welding techniques for propeller**~~④ **Table 8.4.5.3(1)**

Material of propeller	Min. thickness of assembly④ (mm)	Test item	Requirements for test results⑤⑥
Cast copper alloy propeller	30	Visual inspection and liquid penetrant testing④①: weld length	No surface cracking, satisfying the requirements for Zone A in Table 8.4.3.7
		Radiographic testing: weld length	In compliance with recognized standards
		Transverse tensile: 2	CU1: R_m≥370 N/mm^2 CU2: R_m≥410 N/mm^2 CU3: R_m≥500 N/mm^2 CU4: R_m≥550 N/mm^2
		Macrosection examination : 3	No cracking, lack of fusion, slag inclusions or pores ~~and slag inclusions~~ over 3 mm in diameter at welds and heat affected zones
		Bending or fracture test (if required)	In compliance with recognized standards
Cast steel propeller	-	Visual inspection and liquid penetrant testing④①: weld length	No cracking and sSatisfying requirements for Zone A in Table 8.4.3.7
		Radiographic testing: weld length	In compliance with recognized standards
		Transverse tensile: 2	R_m satisfies the minimum requirements

			specified for base metal, the location of fracture is to be reported
		Bend[①②]: Two root and two face bend specimens	Bend degree: 180° Diameter of former: austenitic stainless steel 3*t*, other materials 4*t*; after the specimens are bent, they are not to exhibit cracking over 3 mm in length on the surface; defects appearing at the corners of a test specimen during testing are to be investigated case by case by CCS.
		Macrosection examination[③]: ~~2~~3	No cracking, lack of fusion, slag inclusions or pores over 3 mm in diameter at welds and heat affected zone ~~No cracking or defects similar to cracking, no slag inclusions or pores over 3 mm in diameter~~
		Impact: where there are impact requirements for base metal, one set for the center weld and the heat affected zone (1-2 mm from the fusion line) for Charpy V-notch impact test ~~and the fusion line respectively~~	The impact temperature and impact energy satisfy the requirements for base metal
		Hardness[④]: start of welding	Reported for information

Notes: ~~① For the repair of cast copper alloy propellers, the test items and requirements specified in the Table are also applicable to the welder's qualification test.~~

~~② Back sealing runs are allowed in single V weld assemblies. The specimen is in general to be welded in down-hand (flat) position.~~

~~③~~① Test assembly is to be examined by visual and liquid penetrant testing prior to the cutting of test specimen. In case that any post-weld heat treatment is required or specified, non-destructive testing is to be performed after heat treatment. Magnetic particle testing may be used in lieu of liquid penetrant testing for martensitic stainless steels.

~~④~~② For thickness of 12 mm and over, four side bend specimens may alternatively be tested in lieu of root and face bend specimens.

③ Macroscopic test specimens are to be prepared and etched on one side to clearly reveal the weld metal, the fusion line and the heat affected zone. For cast copper alloy, a suitable etchant is: 5g iron (III) chloride, 30ml hydrochloric acid (cone) and 100ml water.

④ Vickers hardness tester is to be used and a force of 98N is to be applied. Indentations are to traverse 2mm below the surface. At least three individual indentations are to be made in the weld metal, the HAZ (both sides) and in the base metal (both sides).

⑤ Specimens are to be prepared and tested in compliance with Section 2, Chapter 1, PART THREE or a recognized standard. If the test result fails to comply with any of the requirements, reference is made to re-test procedures given in Section 2, Chapter 1, PART THREE.

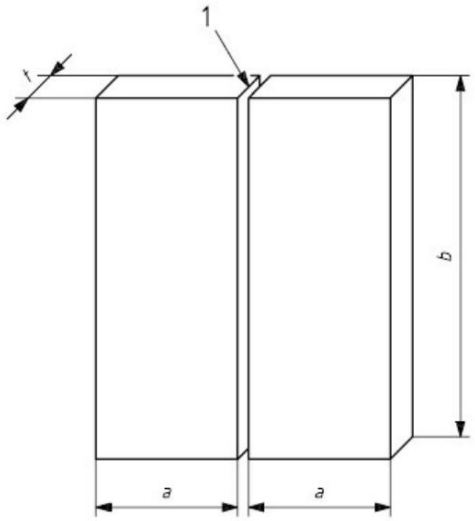
⑥ Welding conditions for test assemblies and test results are to be recorded in welding procedure qualification record. A statement of the results of assessing each test piece, including repeat tests, is to be made for each welding procedure qualification records. Forms of welding procedure qualification records and welding procedure specification are to in accordance with the relevant requirements in Section 1 of Chapter 3 of PART THREE.

Range of propeller repair welding procedure qualification test ~~Range of approval of repair welding techniques for propeller~~ Table 8.4.5.3(2)

Parameters	Range of approval[①]	
Base metal	Materials (materials grade):	Range of materials of approval:
	CU1	CU1
	CU2	CU1, CU2
	CU3	CU3
	CU4	CU4
	Cast steel	Same steel grade
Thickness	Cast Copper alloy t≥30mm	≥3mm
	Cast steel 15<t≤30mm	3mm-2t
	Cast steel t>30mm	0.5t to 2t or 200mm, whichever is greater
Welding position	Approval for a test made in any position is restricted to that position.	
Welding process	The approval is only valid for the welding process used in the welding procedure test. Single run is not qualified by multi-run butt weld test.	
Filler metal	The approval is only valid for the filler metal used in the welding procedure test.	
Heat input	Copper alloy::The upper limit of heat input approved is 25% greater than that used in welding the test piece. The lower limit of heat input approved is 25% lower than that used in welding the test piece.	

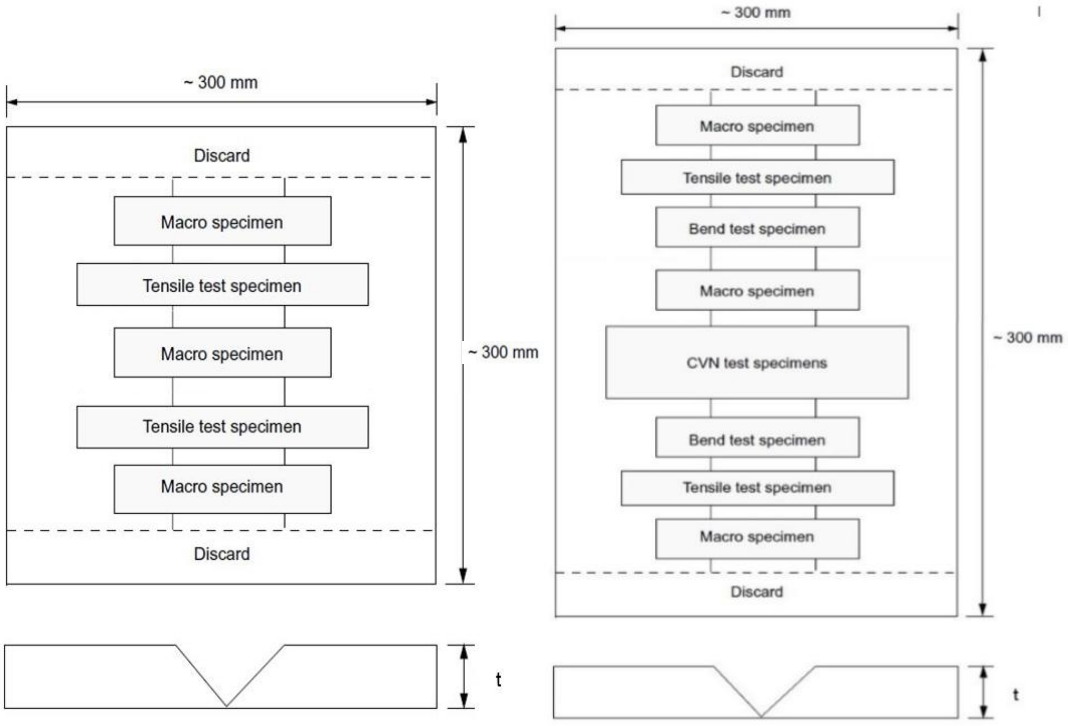
	Cast steel::The upper limit of heat input approved is 15% greater than that used in welding the test piece. The lower limit of heat input approved is 15% lower than that used in welding the test piece.
Preheating temperature Interpass temperature	The minimum preheating temperature is not to be less than that used in the qualification test. The maximum interpass temperature is not to be higher than that used in the qualification test.
Post-weld heat treatment	The heat treatment used in the qualification test is to be specified in pWPS. Soaking time may be adjusted as a function of thickness.

Note: ① All the conditions of validity are to be met independently of each other. Changes outside of the ranges specified are to require a new welding procedure test.



The test assembly, consisting of cast samples, is to be of a size sufficient to ensure a reasonable heat distribution. In the above figure, the minimum value of a is 150mm, the minimum value of b is 300mm, t is the material thickness. Joint preparation and fit-up are to be detailed in the preliminary welding procedure specification. The dimensions and shape of the groove are to be representative of the actual repair work. Preparation and welding of test pieces are to be carried out in accordance with the general condition of repair welding work which it represents.

Figure 8.4.5.3(1) Test piece for approval of welding repair procedure for propellers



(1) Cast copper alloy propeller (2) Cast steel propeller

Figure 8.4.5.3(2) Test specimen locations for approval of repair welding ~~techniques~~ procedure for propeller

8.4.7 Heat treatment

8.4.7.1 Unless demonstrated by the manufacturer as not necessary, all cold straightening or weld repairs of CU1, CU2 and CU4 copper alloy propellers are to be stress relief heat treated. Stress relief heat treatment of alloy CU3 propeller castings may be required after 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 range 450-500℃ or annealed in the temperature range 650-800℃, depending on the extent of repair.

8.4.7.2 The martensitic steels are to be furnace re-tempered after weld repair. Other cast steel propellers may be subject to post-weld heat treatment according to 6.1.10.9 of Chapter 6 of PART ONE after weld repair. Subject to prior approval, however, local stress relieving may be considered for minor repairs.

8.4.7.3 The recommended stress relief heat treatment temperatures for copper alloy propellers are listed in Table 8.4.7.3. Soaking times are to be in accordance with Table 9.1.4.4 in Chapter 9 of PART ONE of the Rules.

Recommended Filler Metals, Preheating and Heat Treatment Temperatures Table 8.4.7.3

Alloy type	Filler metal	Min preheating temperature ℃	Max. interpass temperature ℃	Stress relief temperature ℃	Hot straightening temperature ℃
CU1	Al-bronze① 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-bronze② Mn-Al-bronze	100	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.

APPENDIX 1 NON-DESTRUCTIVE TESTING OF SHIP HULL STEEL WELDS

8.5 In addition to generic items, reports of RT are to include the following specific items:
(1)Type and size of radiation source (width of radiation source), X-ray voltage;
(2)Type of film/designation and number of film in each film holder/cassette;
(3) Number of radiographs (exposures);
(4)Type of intensifying screens;
(5)Exposure technique, time of exposure and source-to-film distance as per below:
~~(6)~~ ① Distance from radiation source to weld;
~~(7)~~ ② Distance from radiation source side of the weld to radiographic film;
~~(8)~~(6)Angle of radiation beam through the weld (from normal);
~~(9)~~ (7)Sensitivity, type and position of IQI (source side or film side);
~~(10)~~ (8)Density;
~~(11)~~ (9) Geometric un-sharpness;
~~(12)~~ (10)Specific acceptance class criteria for RT.