



CHINA CLASSIFICATION SOCIETY

**RULES FOR MATERIALS
AND WELDING**

AMENDMENTS

2018



人民交通出版社股份有限公司
China Communications Press Co.,Ltd.



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Effective from July, 1 2018

Beijing

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PART ONE METALLIC MATERIALS

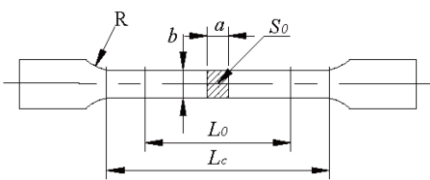
CHAPTER 2 MATERIAL TESTS

Section 2 TENSILE TESTS

2.2.2.1 Tensile specimens are to be of the type and dimensions as given in Table 2.2.2.1. Both ends of the test specimen may be machined to suit the grips of the testing machine used.

Type and Dimensions of Tensile Specimens

Table 2.2.2.1

Item	Type of specimen	Dimensions of specimen (mm) ^①	Applicable materials
1	Flat	 <p>Proportional test specimen: $a=t$, $b=25$, $R=25$ $L_0=5.65\sqrt{S_0}$ $L_c=L_0+2\sqrt{S_0}$</p> <p>Non-proportional test specimen: 1: $a=t$, $b=25$, $R=25$ $L_0=200$, $L_c\geq 212.5$</p> <p>2: $a=t$, $b=12.5^{\oplus}$, $R=25$, $L_0=50$, $L_c\geq 55$</p>	Steel plates, strips and sections ^②
.....

Section 7 INTERCRYSTALLINE CORROSION TESTS OF STAINLESS STEEL

2.7.1 General requirements

2.7.1.1 Intercrystalline corrosion tests of stainless steel are mainly used to evaluate basic corrosion-resisting properties of austenitic stainless steels and austenitic/ferritic duplex stainless steel.

2.7.2 Preparation of test specimens

2.7.2.1 The material for the intercrystalline corrosion test of stainless steel is to be taken adjacent to that for the tensile test.

2.7.2.2 The total surface area of test specimens of intercrystalline corrosion tests is to be between 12 cm^2 and 35 cm^2 . For rolled plates and tubes with external diameter over 56 mm, bend specimen with thickness not more than 6 mm and width not less than 10 mm is to be used. For steel bars with diameter not more than 12 mm, bend specimens may be taken directly from the round section. Where the thickness or diameter of the product is more than 6 mm or 12 mm respectively, one side of the product may be machined so that the thickness is reduced to 6 mm. The rolled side of the specimen is to be stretched during bending.

For small-diameter tubes with external diameter not greater than 5660 mm, test pieces may be cut directly as the specimen for flattening test.

2.7.2.3 For butt weld joint, test piece is to be cut from a test specimen of the same base material, welding material and welding procedures as the weld joint under investigation. Longitudinal bending test piece with thickness not more than 6 mm is to be used. Where the thickness of the test piece is more than 6 mm, the test piece is to be machined down to 6 mm from one side. The retained surface is in contact with corroding media and is to be stretched during bending test. The requirements for the sizes of test pieces of plate joint and tube joint are as follows:

(1) For flat plates with welded butt joint, longitudinal bending test pieces of 50 mm wide and 100 mm long are to be selected.

(2) For welded tubes with outer diameter over 60 mm and with welded butt joint, test pieces are to be selected in a boat shape in parallel with the weld bead. The size of the test pieces is shown in the above (1).

(3) For welded tubes with outer diameter over 60 mm and with longitudinal weld bead, longitudinal bending test pieces in parallel with the weld bead are to be selected, with width of at least 20 mm and length of at least 50 mm.

(4) For welded tubes up to 60 mm outside diameter, test pieces can be subject to a flattening test.

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 ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) into 700 ml~800 ml distilled water;
- (2) add 100 ml sulphuric acid (relative density 1.84 g/ml) 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 ~~filled with the corroding solution in the ratio of 50g per liter of solution~~ to form a bed of copper turnings, and the ratio of the copper turnings to the solution is at least 50 g/L, ~~and the solution is to be heated to boiling point.~~

2.7.3.3 Cleaned specimens are to be subject to sensitization heat treatment (except for weld joint specimen): heated to a temperature of $700 \pm 10^\circ\text{C}$ 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 ~~corroding media~~ solution for not less than 16 h, unless for a longer time agreed between the supplier and the user. (but not more than 24 h). 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.

2.7.3.4 After immersion, each test specimen is to be bent under the conditions specified in Table 2.7.3.4.

Bending Radius and Angle of Test Specimens of Intercrystalline Corrosion Tests

Table 2.7.3.4

Product type	Radius of former	Bending angle
Rolled product	Diameter or thickness of the specimen	90°
Forged product	Twice the thickness of the specimen	90°
<u>Weld joint</u>	<u>Twice the thickness of the specimen</u>	<u>90°</u>

Note: For duplex stainless steel, radius of former may be determined according to the agreement, and its maximum value is not to be more than twice the thickness of the specimen.

Test specimens of small-diameter tubes may be subject to flattening tests as required by Section 6 of this Chapter.

2.7.3.5 After bending or flattening, magnifying glass with not more than 10 times magnification is to be used to observe the stretched surfaces of the test specimens, which are to be free from cracks due to intercrystalline corrosion (cracking at edges, and the appearance of deformation lines, wrinkles, or “orange peel” on the surface are all disregarded).

2.7.3.6 When the above test results are questionable, a metallographic examination of a longitudinal cross section of the test piece may be carried out.

CHAPTER 3 STEEL PLATES, FLAT BARS AND SECTIONS

Section 1 GENERAL PROVISIONS

3.1.1 Application

3.1.1.1 This Chapter applies to steel plates, flats, sections and bars ~~flat bars or sections~~ intended for use in the construction of hull, machinery, boilers, pressure vessels and offshore installations, etc.

3.1.1.3 Normal and higher strength corrosion resistant hull structural steels used as the alternative means of coating for crude oil tanks are to comply with, in addition to the relevant requirements of this Chapter, the relevant requirements of CCS Guidelines for Survey of Corrosion Resistant Steel of Cargo Oil Tanks in Crude Oil Tankers.

3.1.2 Manufacture

3.1.2.2 Steel is ~~The steels are~~ to be manufactured by open hearth, electric, ~~or~~ basic oxygen processes or by other processes specially approved by CCS. The deoxidation method used for each grade is to comply with the relevant requirements of subsequent Sections of this Chapter. ~~The use of other processes is to be subjected to special approval of CCS.~~

3.1.2.4 Rolling practice and heat treatment method applied for steel is to comply with the appropriate conditions of supply as specified in relevant sections in this Chapter .

~~3.1.2.5 The definitions of applicable rolling and heat treatment procedures are given as follows. Steels may be produced by as rolled (AR), controlled rolling (CR) or thermo-mechanical controlled processing (TMCP). The principle diagrams of different processes are shown in Figure 3.1.2.54. The specified tests are to be carried out under the supervision of the Surveyor. The test results are to comply with the test requirements, and relevant information concerning technological properties and weldabilities are to be submitted for information.~~

(1) As Rolled, AR

This procedure involves steel being cooled as it is rolled with no further heat treatment. The rolling and finishing temperatures are typically in the austenite recrystallization region and above the normalising temperature. The strength and toughness properties of steel produced by this process are generally less than steel heat treated after rolling or than steel produced by advanced processes.

(2) Normalising, N

Normalising involves heating rolled steel above the critical temperature, A_{c3} , and in the lower end of the austenite recrystallization region for a specific period of time, followed by air cooling. The process improves the mechanical properties of as rolled steel by refining the grain size and homogenising the microstructure.

(3) Controlled Rolling, CR (Normalizing Rolling, NR):

A rolling procedure in which the final deformation is carried out in the normalizing temperature range, allowed to cool in air, resulting in a material condition generally equivalent to that obtained

by normalising.

(4) Quenching and Tempering, QT

Quenching involves a heat treatment process in which steel is heated to an appropriate temperature above the Ac3, held for a specific period of time, and then cooled with an appropriate coolant for the purpose of hardening the microstructure. Tempering subsequent to quenching is a process in which the steel is reheated to an appropriate temperature not higher than the Ac1, maintained at that temperature for a specific period of time to restore toughness properties by improving the microstructure and reduce the residual stress caused by the quenching process.

(5) Thermo-Mechanical Rolling, TM (Thermo-Mechanical Controlled Processing, TMCP):

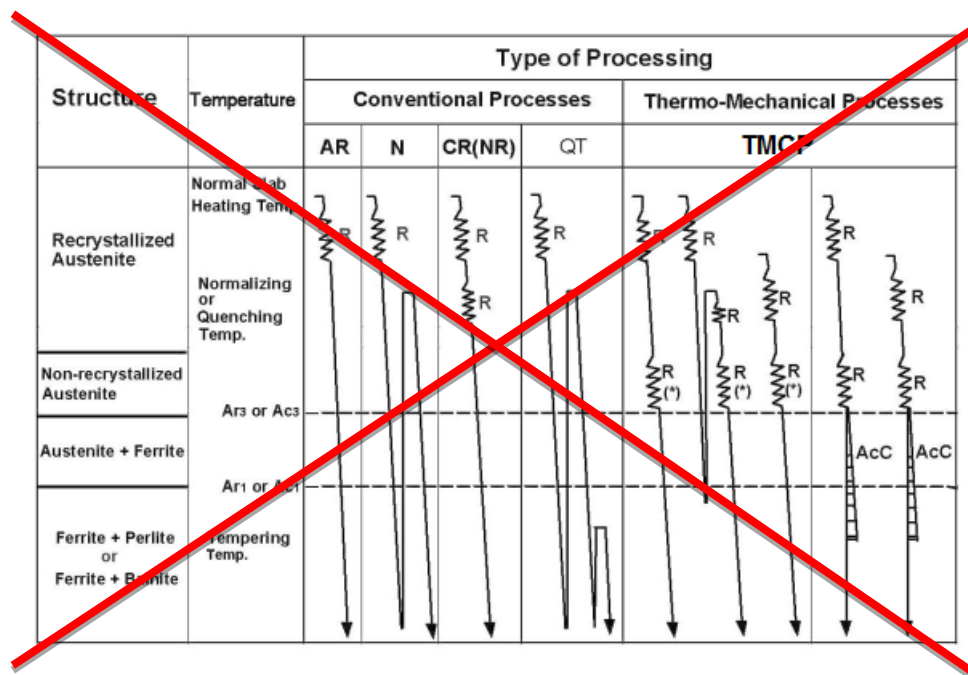
This is a procedure which involves the strict control of both the steel temperature and the rolling reduction. Generally a high proportion of the rolling reduction is carried out close to the Ar3 temperature and may involve the rolling in the dual phase temperature region. Unlike controlled rolled (normalised rolling) the properties conferred by TM (TMCP) cannot be reproduced by subsequent normalising or other heat treatment.

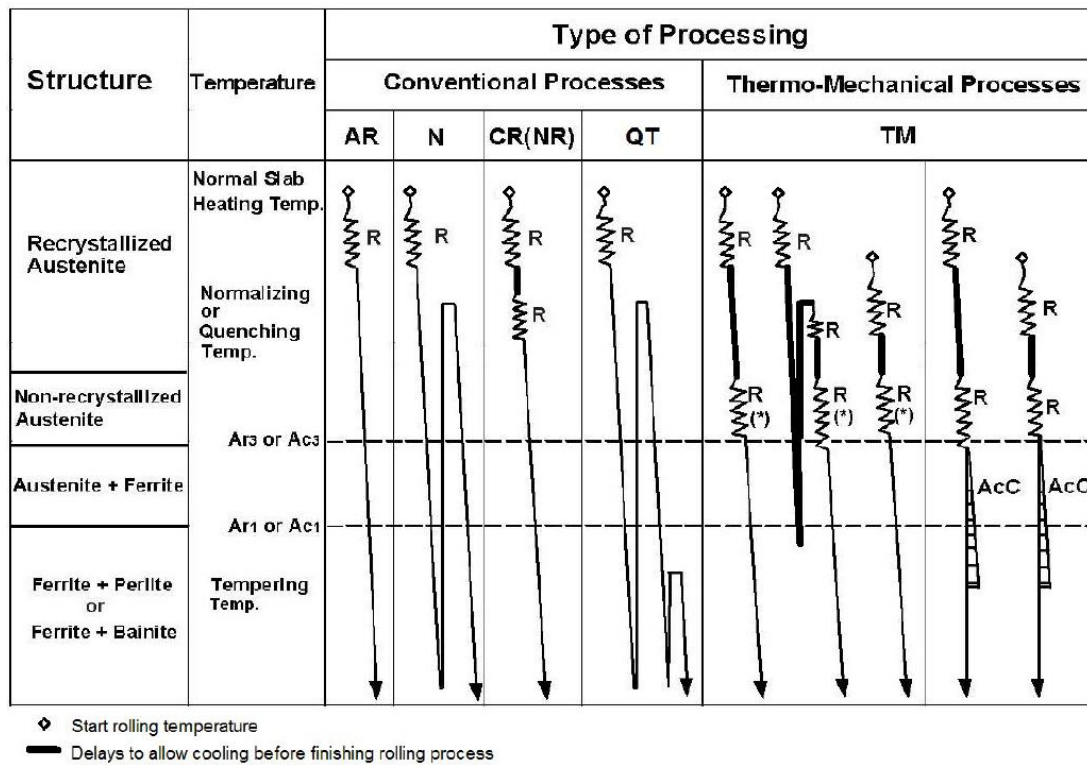
The use of accelerated cooling on completion of TM-rolling may also be accepted subject to the special approval of CCS. The same applies for the use of tempering after completion of the TM-rolling.

(6) Accelerated Cooling, AcC

Accelerated cooling is a process, which aims to improve mechanical properties by controlled cooling with rates higher than air cooling immediately after the final TM-rolling operation. Direct quenching is excluded from accelerated cooling.

The material properties conferred by TM and AcC cannot be reproduced by subsequent normalising or other heat treatment.





Notes: AR—As-rolled; N—Normalizing; CR(NR)—Controlled rolling (normalized rolling); QT—Quenching and tempering; TM—Thermo-mechanical controlled process; R—Reduction; (*) Sometimes rolling in the dual-phase temperature region of austenite and ferrite; AcC—Accelerated cooling.

Figure 3.1.2.4 Schematic diagram of steel rolling processes

3.1.2.56 It is the manufacturer's responsibility to ensure that ~~effective~~ proper process and ~~effective~~ production controls in operation are adhered to within the manufacturing specifications. To this effect, the actual rolling records are to be reviewed by the manufacturer and occasionally by the Surveyor.

3.1.2.6 When deviation from the programmed rolling schedules or normalizing or quenching and tempering procedures occurs, or where control imperfection inducing possible inferior quality of product occurs, Where other deviation from the control and/or inferior quality of products exists, the manufacturer is to:

- (1) find the reasons and take measures to prevent it from reoccurrence. Meanwhile, a report is to be submitted to the Surveyor for information.
- (2) Where the affected steel is required to be used, the manufacturer is to carry out the test for each affected piece and the results are to comply with the requirements of the Rules.
- (3) The frequency of testing subsequent products offered may be increased to gain confidence in the quality at the discretion of CCS.

3.1.2.7 The specified tests on mechanical properties are to be carried out in the presence of the Surveyor or his authorized deputy.

3.1.5 Surface inspection and non-destructive examination

3.1.5.1 ~~Surface inspection and verification of dimensions are the responsibility of the steelmaker and are to be carried out on all materials. Except for the under thickness tolerance, the positive deviation of length, breadth, plate shape and thickness of steels is to be in compliance with the requirements of GB or international standards. For accepted material, where the material is found defective by the shipbuilder during working, the steelmaker will not be absolved from this~~

responsibility. Visual inspection and verification of dimensions on all steels for meeting relevant quality requirements are the responsibility of the steel maker, who is to take the necessary manufacturing precautions and is to inspect the products prior to delivery. At that stage, however, rolling or heat treatment scale may conceal surface discontinuities and defects. If the material is found to be defective during the subsequent descaling or working operations, CCS may require materials to be repaired or rejected (refused/removed).

3.1.5.2 Materials intended for hull structures are to be of a sound and uniform quality, and free from cracks, injurious surface flaws, injurious laminations and similar defects. Segregations and non-metallic inclusions in the steel are as far as practicable to be minimized or eliminated. The surface quality inspection method is to be in accordance with recognized national or international standards agreed between purchaser and manufacturer, accepted by CCS. The finished material is to have a surface quality in accordance with a recognized standard such as EN 10163, or an equivalent standard accepted by the CCS, unless otherwise specified in this Chapter.

3.1.5.3 The surface quality and inspection method is to be in accordance with recognized national or international standards agreed between the purchaser and manufacturer. For steel plates and wide flats, imperfections of a harmless nature, for example pitting, rolled-in scale, indentations, roll marks, scratches and grooves, regarded as being inherent of the manufacturing process, are permissible irrespective of their number, provided that all of the following conditions are met:

(1) The maximum permissible limits of Class A of EN 10163-2 or limits specified in a recognized equivalent standard accepted by CCS, are not exceeded;

(2) The remaining plate or wide flat thickness remains within the average allowable minus thickness tolerance specified in 3.1.3.4 of this Section.

(3) Total affected area with imperfection not exceeding the specified limits in (1) are not to exceed 15% of the total surface in question.

The surface quality and conditions of supply for sections and bars may be accepted according to a recognized standard.

3.1.5.4 Affected areas with imperfections with a depth exceeding the limits specified in 3.1.5.3(1) are to be repaired irrespective of their number.

Cracks, injurious surface flaws, shells (over lapping material with non-metallic inclusion), sand patches, laminations and sharp edged seams (elongated defects) visually evident on surface and/or edge of plate are considered defects, which would impair the end use of the product and which require rejection or repair, irrespective of their size and number.

3.1.5.5 Unless otherwise specified in relevant Sections of this Chapter, the non-destructive examination of materials is not required for acceptance purposes. However, steelmakers are expected to employ suitable methods for the general maintenance of quality standards. If necessary, the Surveyor may require a non-destructive examination on a random basis in accordance with a recognized standard. The acceptance by the Classification Society's Surveyor CCS of material does not absolve the steelmaker of the responsibility of ensuring the internal quality of the material. If plates and wide flats are ordered with ultrasonic inspection, this is to be made in accordance with a recognized an accepted standard at the discretion of CCS.

3.1.6 Rectification of defects

3.1.6.1 For plates or wide flats materials intended for structural purposes as detailed in Sections 2, 3, 4 and 6 of this Chapter, surface defects may be removed by grinding provided all the conditions below are adhered to: surface defects may be removed by local grinding provided that:

a) the thickness in no place is to be reduced to less than 93% of the nominal thickness and in no case by more than 3 mm;

b) any single area so ground does not exceed 0.25 m² and that the total area so ground does not exceed 2% of the total surface;

~~e) the ground areas have smooth transitions to the surrounding surface;~~

~~d) for high strength steels for welded structures as specified in section 4 of this Chapter, where repair by grinding is carried out then the remaining plate thickness below the ground area must be within the allowable under thickness tolerance.~~

~~(1) Each single ground area does not exceed 0.25 m². (Ground areas lying in a distance less than their average breadth to each other are to be regarded as one single area.) All ground areas do not exceed 2% of the total surface in question;~~

~~(2) The nominal product thickness will not be reduced by more than 7% or 3 mm, whichever is the less;~~

~~(3) Ground areas lying opposite each other on both surfaces are not to decrease the product thickness by values exceeding the limits as stated under (2);~~

~~(4) Defects or unacceptable imperfections are to be completely removed by grinding and the remaining plate or wide flat thickness is to remain within the average allowable minus thickness tolerance specified in 3.1.3.4 of this Section;~~

~~(5) The ground areas are to be a smooth transition to the surrounding surface of the product;~~

~~(6) Complete elimination of the defect is to be verified by magnetic particle or by liquid penetrant testing.~~

~~Such rectification is to be carried out in the presence of the Surveyor. When necessary, the Surveyor may request that the complete removal of the defect be proven by suitable non-destructive examination of the affected area.~~

~~3.1.6.2 Except for the welding repair procedures for high strength steels for welded structures as specified in section 4 of this Chapter which is to be subject to special approval by CCS, surface defects which cannot be dealt with as in 3.1.6.1 above may be repaired by chipping or grinding followed by welding, subject to agreement of CCS the Surveyor and under his supervision, provided that:~~

~~(1) after removal of the defect and before welding, the thickness of the piece is in no place reduced by more than 20% of the nominal thickness;~~

~~(2) any one single welded area is not to exceed 0.125 m² and the total welded area is not to exceed 2% of the total area of the surface in question surface area;~~

~~(3) two defects repaired welded areas are considered as one defect where the distance between them is less than their average width;~~

~~(4) after removal of the defect and before welding, the thickness of the material is not to be less than 80% of the nominal thickness. For occasional defects with depths exceeding the limit, special consideration at the Surveyor's discretion will be necessary;~~

~~(5) elimination of the defect is proven by suitable non-destructive examination of the affected area;~~

~~(6) the repair is to be carried out by qualified welders using an approved method and procedure for the appropriate steel grade. The electrodes are to be of low hydrogen type and be dried in accordance with the manufacturer's requirements and protected against rehumidification before and during welding; welding is carried out by an approved procedure and by competent operators using approved electrodes and the repaired area is ground smooth and subjected to non-destructive examination for proving good welding quality;~~

~~(7) after welding, the repaired area is to be ground smooth and subjected to magnetic particle or liquid penetrant testing for proving good welding quality. If weld repair depth exceeds 3 mm, UT may be requested by CCS. If required, UT is to be carried out in accordance with an approved procedure;~~

(6) if required by the Surveyor, the item is normalized or otherwise suitably heat-treated after welding and grinding.

3.3.2.2 The carbon equivalent C_{eq} may be required, which is to be calculated from the ladle analysis using the following formula:

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

The maximum value of the carbon equivalent is not to exceed the agreed permissible value.

Section 2 NORMAL STRENGTH HULL STRUCTURAL STEELS

3.2.4.3 The mechanical properties of normal strength hull structural steels are to comply with Table 3.2.4.3.

Mechanical Properties of Normal Strength Hull Structural Steel Table 3.2.4.3

Grade	Yield strength R_{eH} min. (N/mm ²)	Tensile strength R_m (N/mm ²)	Elongation A_5 min. (%)	Charpy V-notch impact test						
				Test temp. (°C)	Average impact energy min. (J)					
					Thickness t (mm)					
					$t \leq 50$		$50 < t \leq 70$		$70 < t \leq 150$	
	Long. ^②	Trans. ^②	Long.	Trans.	Long.	Trans.				
A	235	400 – 520 ^①	22	20	–	–	34 ^④	24 ^④	41 ^④	27 ^④
B				0	27 ^③	20 ^③				
D				-20						
E				-40						

Notes: ① For sections in Grade A, the upper limit of the tensile strength range as specified in the Table may be exceeded subject to special approval of CCS.

② Generally for product thickness t not exceeding 50 mm, impact tests need only be made in the longitudinal direction, except when required by the purchaser or CCS; however, satisfactory transverse test results for plates and wide flats are to be guaranteed by the manufacturer.

③ Grade B steel up to 25 mm in thickness may be exempted from impact tests subject to agreement of CCS.

④ Impact tests for Grade A steels over 50 mm in thickness are not required when the steels are manufactured by grain refining treatment and supplied in a normalized condition; Grade A steels supplied in TMCP condition may be accepted without impact tests subject to special approval of CCS.

⑤ Transverse impact tests are generally not required for sections.

Section 3 HIGHER STRENGTH HULL STRUCTURAL STEELS

3.3.2.3 For steels supplied in TMCP condition, the following requirements are also to be complied with:

(1) The carbon equivalent C_{eq} is to be calculated from the chemical composition of ladle samples using the formula given in 3.3.2.2 of this Section, and is to comply with Table 3.3.2.3(1).

Carbon Equivalent C_{eq} of TMCP Higher Strength Steel up to 100 150 mm in Thickness

Table 3.3.2.3(1)

Grade	Carbon equivalent ^① C_{eq} (%)		
	Thickness t (mm)		
	t	$50 < t \leq 100$	$100 < t \leq 150$
AH32, DH32, EH32, FH32	≤ 0.36	≤ 0.38	≤ 0.40
AH36, DH36, EH36, FH36	≤ 0.38	≤ 0.40	≤ 0.42
AH40, DH40, EH40, FH40	≤ 0.40	≤ 0.42	≤ 0.45

Note: It is a matter for the manufacturer and the shipbuilder to mutually agree in individual cases as to whether they wish to specify a more stringent carbon equivalent.

CHAPTER 4 STEEL PIPES AND TUBES

Section 1 GENERAL PROVISIONS

4.1.1.5 Pipes and tubes for submarine piping systems and pipes and tubes for offshore engineering steel structures or for transfer of liquid may be manufactured, tested and accepted in accordance with relevant recognized standards.

4.1.6.2 For pipes for Class I and II pressure systems and boiler and superheater tubes, the requirements of Table 4.1.6.2 are to be followed, at least 2% of the number of lengths in each batch is to be selected at random, and test specimens are to be cut from each selected length.

4.1.6.3 For pipes for Class II pressure systems, each batch is to contain not more than the number of lengths given in Table 4.1.6.3. Test specimens are to be cut from at least one pipe selected at random from each batch or part thereof.

Number in Batch of Pipes for Class II **Table 4.1.6.23**

Grade	Outside diameter D (mm)	Number in batch (piece) ^①
<u>Class I</u>	All	<u>50</u>
<u>Class II</u>	<u>$D \leq 325$ $D > 325$</u>	<u>200</u> <u>100</u>
	<u>$D > 325$ $D \leq 325$</u>	<u>100</u> <u>200</u>

Note: ① If a steel pipe is made from one slab by rolling and is not subject to heat treatment after saw-cut, all of the sections cut from this pipe can be regarded as one pipe during calculation.

4.1.6.34 Pipes and tubes are to be tested and evaluated and with the test samples prepared in accordance with the relevant requirements given in this Chapter and Chapter 2 of this PART.

4.1.6.45 Normally, longitudinal test specimens are to be taken from the pipes. Where the diameter of pipes is 200 mm or more, test specimens may also be taken transverse to the pipe's axis.

4.1.7.1 All pipes for Class I and II pressure systems, boiler and super heater tubes are to be presented for visual examination of the internal and external surfaces and verification of dimensions by the Surveyor.

CHAPTER 5 STEEL FORGINGS

Section 3 FORGINGS FOR SHAFTING AND MACHINERY

5.3.6 Non-destructive examination

5.3.6.1 Non-destructive examination ~~Magnetic particle testing~~ is to be carried out on the following forgings forged components required to be subject to non-destructive examination in Section 2, Chapter 9, PART THREE of CCS Rules for Classification of Sea-going Steel Ships in accordance with the requirements of 5.1.6 of this Chapter.:

(1) ~~all connecting rod forgings;~~

(2) ~~the following components when intended for diesel engines having a bore diameter larger than 400 mm:~~

— ~~cylinder covers;~~

— ~~piston crowns;~~

— ~~piston rods;~~

— ~~tie rods;~~

— ~~gear wheels for camshaft drives;~~

— ~~bolts and studs for cylinder covers, crossheads, main bearings and connecting rod bearings.~~

5.3.6.2 Ultrasonic testing is to be carried out on shafts having a finished diameter of 250 mm or

larger when intended for main propulsion such as tube shafts, screwshafts, thrust shafts, intermediate shafts and shafts for other essential services ~~the following forgings~~ in accordance with the requirements of 5.1.6 of this Chapter:

- ~~(1) shafts having a finished diameter of 250 mm or larger when intended for main propulsion such as tube shafts, screwshafts, thrust shafts, intermediate shafts and shafts for other essential services;~~
- ~~(2) all piston crowns and cylinder covers;~~
- ~~(3) piston and connecting rods for diesel engines having a bore diameter greater than 400 mm.~~

5.3.6.3 The non-destructive examination for other forgings may be carried out in accordance with the requirements given in the drawings approved by CCS.

Section 4 FORGINGS FOR CRANKSHAFTS

5.4.5.1 The following tests are to be carried out on each crankshaft forging:

- (1) tensile test;
- (2) impact test;
- (3) hardness test (if applicable).
- ~~(4) macro-examination (only applicable to forgings with a diameter not greater than 250 mm and directly made from ingots).~~

5.4.7 Non-destructive examination

5.4.7.1 Non-destructive examination ~~Magnetic particle testing~~ is to be carried out on ~~all machined surfaces of the crankshaft forgings of diesel engines required to be subject to non-destructive examination in Section 2, Chapter 9, PART THREE of CCS Rules for Classification of Sea-going Steel Ships in accordance with the requirements of 5.1.6 of this Chapter,~~ and particular attention is to be given to the following positions during magnetic particle testing:

- (1) pins, journals and associated fillet radii of solid forged crankshafts;
- (2) pins and fillet radii of combined web and pin forgings.

5.4.7.2 The non-destructive examination for other forgings for crankshafts may be carried out in accordance with the requirements given in the drawings approved by CCS ~~All forgings for crankshafts with crank pin diameter not less than 150 mm are to be ultrasonically tested.~~

Section 6 FORGINGS FOR TURBINES

5.6.2.1 For forgings in carbon or carbon-manganese steel the chemical composition of ladle samples is to comply with Table 5.6.2.1.

Chemical Composition of Forgings for Turbines **Table 5.6.2.1**

Steel type	Chemical composition (%)				
	C	Mn	Si	S	P
Carbon and carbon-manganese steel	≤ 0.45	≥ 0.40	≤ 0.45	≤ 0.035	≤ 0.035

Note: Where forgings are intended for welded construction, the carbon content is in general not to exceed 0.23%.

CHAPTER 6 STEEL CASTINGS

Section 1 GENERAL PROVISIONS

6.1.6.3 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 ~~based on the typical thickness of steel castings and~~ in accordance with a recognized standard (e.g. ISO 4990) and at least to be 28 mm in thickness. Test samples are to be properly identified and heat treated together with the castings they represent.

6.1.10.9 After completion of welding, the castings are to be ~~given heat treatment according to the existing requirements for heat treatment or~~ given a stress relieving heat treatment at a temperature of not less than 550°C, or given heat treatment as appropriate according to the chemical composition of castings, repair size, position and feature. ~~according to the existing requirements for heat treatment. Post-weld local stress relieving heat treatment may be used for cosmetic repairs.~~

6.1.10.10 For small defects found during finish machining, heat treatment may be waived or local heat treatment may be carried out subject to agreement by CCS.

6.1.10.11 On completion of post-weld heat treatment, the weld repairs and adjacent material are to be ground smooth 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 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. These records are to be available to the Surveyor and copies provided on request.

CHAPTER 8 ALUMINIUM ALLOYS

Section 2 ALUMINIUM ALLOY PLATES AND SECTIONS

8.2.5.7 The manufacturer has to demonstrate by macrosection tests or drift expansion tests of closed profiles performed on each batch of closed profiles that there is no lack of fusion at the press welds. Drift expansion tests may be carried out in accordance with the following requirements:

- (1) Every fifth profile is to be sampled after final heat treatment. Batches of five profiles or less are to be sampled one profile. Profiles with lengths exceeding 6 m are to be sampled every profile in the start of the production. The number of tests may be reduced to every fifth profile if the results from the first 3~5 profiles are found acceptable.
- (2) Each profile sampled is to have two samples cut from the front and back end of the production profile.
- (3) The test specimens are to be cut with the ends perpendicular to the axis of the profile. The edges of the end may be rounded by filing.
- (4) The length of the specimen is to be in accordance with 2.6.2, Chapter 2 of this PART.
- (5) Testing is to be carried out at ambient temperature and is to consist of expanding the end of the profile by means of a hardened conical steel mandrel having an included angle of at least 60°.
- (6) The sample is considered to be unacceptable if the sample fails with a clean split along the weld line which confirms lack of fusion.

CHAPTER 10 EQUIPMENT

Section 1 ANCHORS

10.1.1.3 Ordinary anchors of 'stockless' type are to be generally adopted and they are to be designed and manufactured in compliance with the standards accepted by CCS.

10.1.1.43 High holding power anchors specified in this Section are anchors of which the holding power is at least not less than twice that of an ordinary stockless anchor having the same mass.

10.1.1.54 Super high holding power anchors specified in this Section are anchors of which the holding power is at least four times that of an ordinary stockless anchor of the same mass or twice that of a high holding power anchor of the same mass. The mass of super high holding power anchors is generally not to be greater than 1,500 kg.

10.1.2 Material

10.1.2.5 The base steel grades in welded Super high holding power anchors are to be selected with respect to the material grade requirements for Class II in CCS Rules for Classification of Sea-going Steel Ships, PART TWO, Chapter 1, Table 1.3.2.2(7). The toughness of the anchor shackles for SHHP anchors is to meet that for Grade 3 accessories in accordance with Table 10.2.8.4 of Section 2 of this Chapter of the Rules.

10.1.2.65 Rolled bars intended for pins, swivels and shackles are to be in accordance with the relevant requirements of Chapters 3 and 5 of this PART.

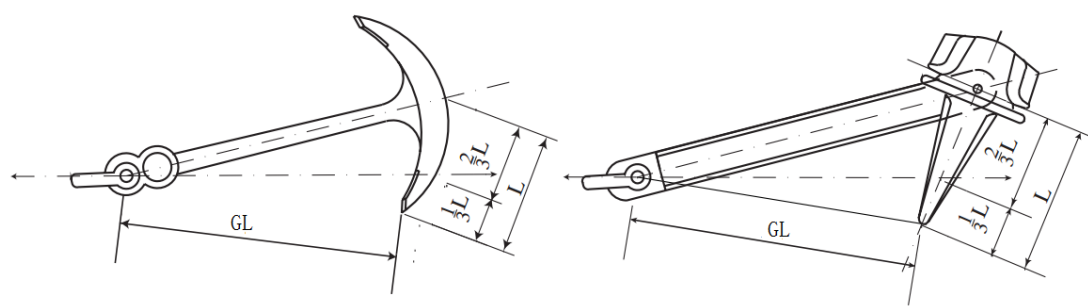
10.1.2.76 The welding consumables used in the manufacturing process are to be compatible with the parent metals and in accordance with the relevant requirements of Chapter 2 of PART THREE of the Rules.

10.1.5 Proof-Load tests of anchors

10.1.5.1 Anchors of all sizes are to be load tested. Prior to the ~~proof~~ load test, examination and confirmation is to be made that no harmful surface defects are found on anchors. The testing machines are to be calibrated ~~and calibrated testing machines are to be approved by CCS.~~

10.1.5.2 The anchors are to be proof-load tested as follows:

(1) The proof load is to be applied to two points, one at the anchor shackle and the other at a point which, measured from the extremity of the bill, is $\frac{1}{3}$ of the distance between it and the center of the crown, as shown in Figure 10.1.5.2(1).



Where: L-- the distance between the extremity of the bill and the center of the crown; GL—Gauge length

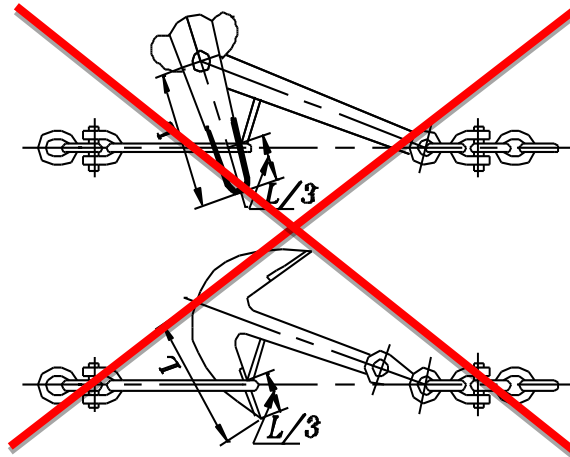


Figure 10.1.5.2(1)

(2) For stockless anchors, both arms are to be tested at the same time, first on one side of the shank, then reversed and tested on the other.

(3) For stocked anchors, each arm is to be tested individually.

(4) Prior to the proof load test, a gauge mark (punched or cut ~~for measuring the gauge length during testing~~) is to be made for each anchor respectively on the shank adjacent to the shackle and near each fluke tip, and gauge length between the two points are to be measured.

(5) During the test, the anchor is first to be subjected to 10% of the required load for a period of 5 min, and then the gauge length is to be measured and recorded. After that, the applied load is to be slowly increased to the required proof load and kept for 5 min, then the load is to be gradually decreased to 10% of the required load, then again the gauge length is to be measured.

10.1.5.4 After proof testing, anchors are to be inspected as follows:

(1) Visual inspection and non-destructive testing: after proof testing, finished anchors are to be subjected to visual inspection and nondestructive testing in accordance with the requirements given in Table 10.1.5.4(1).

(2) Measurement of permanent set (i.e. variation in gauge length): no obvious permanent deformation for stocked anchors, and no permanent set exceeding 1% of the gauge length for stockless anchors.

(3) Free rotation of anchor: fabricated anchors are to be capable of free rotation of their heads over the complete design angle. If the anchor head cannot rotate freely or over the complete angle, such defect is to be rectified and the anchor in question is to be re-tested. If the re-test fails, the anchor is to be rejected.

Visual Inspection and Non-Destructive Testing of Anchors after Proof Load Test

Table 10.1.5.4(1)

Method \ Type		Ordinary anchor	High holding power anchor	Super high holding power anchor
Visual inspection		No cracks or other obvious defects allowable for all stressed parts	No cracks or other obvious defects allowable for all stressed parts	No cracks or other obvious defects allowable for all stressed parts
Non-destructive test#	Magnetic particle or dye penetrant test	Feeders and risers of castings; Welds of fabricated anchors; Repairs by welding of all anchors	Feeders and risers of castings; Welds of fabricated anchors; Repairs by welding of all anchors; Highly stressed areas (if deemed necessary by the Surveyor)	All surfaces of castings; Repairs by welding of all anchors; Welds of fabricated anchors; Highly stressed areas (if deemed necessary by the Surveyor)
	Ultrasonic test	Not required	Welds of fabricated steel anchors (if deemed necessary by the Surveyor)	Welds of fabricated steel anchors; Feeders and risers of castings; Repairs by welding of all anchors;

Method \ Type		Ordinary anchor	High holding power anchor	Super high holding power anchor

Note: Non-destructive tests for steel castings are to be in accordance with the requirements in Sections 1 and 2, Chapter 5 of this PART. Non-destructive tests for steel forgings are to be in accordance with the requirements in Sections 1 and 2, Chapter 6 of this PART. Welds of fabricated steel anchors are to be in accordance with the relevant quality requirements.

10.1.6 Holding power tests

10.1.6.1 For approval of anchors designed as high holding power ones or super high holding power ones, they are to be tested in full scale at sea on various types of bottom (normally, soft mud or silt, sand or gravel and hard clay or similar compounded material) for their holding powers in accordance with the following requirements.

10.1.6.2 The tests are to be applied to anchors of mass which are as far as possible representative of the full range of sizes proposed. Normally the following requirements are to be complied with:

(1) For approval and/or acceptance for a range of HHP anchor sizes, tests at sea are to be carried out for at least two anchor sizes. The larger of the two anchors tested is to have a mass not less than one-tenth of that of the largest anchor for which approval is sought, and the smaller of the two anchors is to have a mass not less than one-tenth of that of the large anchor.

(2) For approval and/or acceptance for a range of SHHP anchor sizes, at least three anchor sizes are to be tested, indicative of the bottom, middle and top of the mass range.

10.1.6.3 For a definite group within the range, the two anchors selected for testing (ordinary stockless anchor and HHP anchor, or ordinary stockless anchor and SHHP anchor, respectively) are to be of approximately the same mass. Where an ordinary stockless anchor is not available, a previously approved HHP anchor or SHHP anchor may be used in its place.

10.1.6.4 The diameter of the chain used in the test is to be appropriate for the anchor to be tested. The length of the cable with each anchor is to be such that the pull on the shank remains horizontal. For this purpose a scope of 10 is considered normal but a scope of not less than 6 may be accepted. Scope is defined as the ratio of length of cable to depth of water.

10.1.6.5 Three tests are to be taken for each anchor and each type of bottom. The stability of the anchor and ease of breaking out are to be noted where possible. Tests are to be carried out from a tug but alternatively shore based tests may be accepted. The pull is to be measured by dynamometer. Measurements of pull, based on the RPM/bollard pull curve of the tug may be accepted as an alternative to a dynamometer. The holding power test load is not to exceed the proof load of the anchor as indicated in Table 10.1.5.3.

~~10.1.6.1 For approval of anchors designed as high holding power ones or super high holding power ones, they are to be tested at sea for their holding powers in accordance with the following requirements:~~

~~10.1.6.2 If approval is sought for a range of sizes of high holding power or super high holding power anchors, at least two sizes are to be tested at sea. The smaller of the two anchors is to have a mass not less than one-tenth of that of the large anchor, and the larger of the two anchors tested is to have a mass not less than one-tenth of that of the largest anchor for which approval is sought.~~

~~10.1.6.3 For holding power tests at sea, comparison is generally to be made to those of stockless anchors of approximately the same mass. Where super high holding power anchors are tested at sea, approved high holding power anchors may be used for comparison.~~

~~10.1.6.4 During testing, the same scope for the anchor cable is to be used for the anchor for which approval is sought and the anchor that is being used for comparison purposes. A scope (defined as the ratio of length of cable to depth of water) of 10 is recommended for the anchor cable, but in no case should a scope of less than 6 be used. A steel wire rope may be used in place of anchor cable for this test.~~

~~10.1.6.5 The tests are to be conducted on not less than three different types of sea bottom, which is normally to be soft mud or silt, sand or gravel, and hard clay or similarly compacted material.~~

~~10.1.6.6 The test is normally to be carried out from a tug, and the pull measured by dynamometer. Measurements of pull based on RPM/bollard pull curves of tug may be accepted instead of dynamometer readings.~~

~~10.1.6.7 High holding power and/or super high holding power anchors are to be of a design that will ensure that the anchors will take effective hold of the seabed without undue delay and will remain stable, for holding forces up to those required by 10.1.1.3 or 10.1.1.4, irrespective of the angle or position at which they first settle on the seabed when dropped from a normal type of hawse pipe. In case of doubt, demonstration of these abilities may be required by the Surveyor. The stability of the anchor and ease of breaking out are to be recorded where possible.~~

~~10.1.6.8 Where it is impracticable to carry out tests at sea, the manufacturer is to propose a test plan subject to agreement of CCS, tests may be carried out on land instead.~~

Section 2 MARINE ANCHOR CHAIN CABLES AND ACCESSORIES

~~10.2.7.3 For the braking load test, one sample comprising of at least three links taken from every four lengths or fraction of chain cables is to be regarded as the specimen by the Surveyor one sample comprising at least of three links is to be taken from every four lengths or fraction of chain cables and tested at the breaking loads given by Table 10.2.7.2. The breaking load is to be maintained for at least 30 s. The links concerned are to be made in a single manufacturing cycle together with the chain cable and welded and heat treated together with it. Only after this may they be separated from the chain cable in the presence of the Surveyor.~~

Where the tensile loading capacity of the testing machine is insufficient to apply the breaking load for chain cables of large diameter, another equivalent testing method is to be agreed.

Where the specimen is not broken after the specified load is applied, it is regarded that the specimen has passed the test.

~~10.2.7.5 For Grades 2 and 3 chain cables, mechanical test specimens are to be taken from every four lengths of welded chain cable. For forged chain cables where the batch size is less than four lengths, the sampling frequency is to be by heat and heat treatment charge. One tensile specimen and two sets of three Charpy V-notch impact test specimens are to be taken from each batch according to the requirements of Table 10.2.7.5. One tensile specimen and one set of three impact test specimens are to be taken from the side of the base material opposite the weld, and the other set of three impact test specimens is to be taken with the notch positioned at the centre of the weld. In order to take the specimens, an additional link (or several links where the links are small) is to be provided in a length of chain cable not containing the specimen for the breaking test. The specimen link is to be manufactured and heat treated together with this batch the length of chain cable.~~

PART TWO NON-METALLIC MATERIALS

CHAPTER 2 PLASTICS MATERIALS

Section 2 RAW MATERIALS

2.2.2.5 The following are to be determined using these samples, the results of which are to comply with the requirements of Table 2.2.2.5. For items not mentioned in the table, the results are to comply with limit values specified in the standards or by the manufacturer:

- (1) density or relative density;
- (2) volume shrinkage after cure;

- (3) Barcol hardness;
- (4) tensile strength;
- (5) elongation at break;
- (6) water absorption (if required);
- (7) temperature of deflection.

Properties for Resin Castings Used for Lay-up **Table 2.2.2.5**

Items	Standard	Unsaturated polyester/vinyl ester resin	Gel coat/topcoat resin/ epoxy resins
Tensile strength (N/mm ²)	ISO527-2	≥45	≥55
Elongation at break (%)	ISO527-2	≥1.5	≥2.5
Flexural modulus of elasticity (N/mm ²)	ISO178	≥2700	≥2700
Flexural strength (N/mm ²)	ISO178	≥80	≥100
Heat deflection temperature (°C)	ISO75-2	≥60 <u>≥75</u>	≥60 <u>≥75</u>
Barcol hardness	ASTM D2583	≥35	≥35
Water absorption (mg)	ISO62	<u>≤80 (hull)</u> <u>≤100 (non hull)</u>	<u>≤80</u> <u>≤70</u>

Note 1: Test samples are to be solidified for 24 h under 50°C.

Note 2: The size of test sample for water absorption is 50 mm × 50 mm × 4 mm, exposure time 672 h at 23°C ±2°C.

2.2.8.5 The physical properties of synthetic bearing materials for rudder stocks, rudder pintles, rudder axles and stern shafts are to comply with the requirements of Table 2.2.8.5. For items not mentioned in the table, the results are to comply with limit values specified in the standards or by the manufacturer.

Requirements for Physical Properties of Synthetic Bearing Materials **Table 2.2.8.5**

Compressive stress ^④ N/mm ²	Compressive modulus ^④ N/mm ²	Friction coefficient	Temperature and water resistance	Volumetric swelling in lubricating medium ^{④③} %	Tensile strength N/mm ²
ISO 604	ISO 604	—	—	ISO 175	ISO 527-2
≥120 ^{④①} ≥85 ^{④②}	≥1500 ^{④①}	≤0.25	Not less than 80% of test value in 2.2.8.4(1)	≤3	≥70

Notes: ~~① Under the condition of 25% compressive straining.~~

②① Vertical to the compression side.

③② Parallel to the compression side, only for bearings of strip shape.

④③ For test of volumetric swelling in lubricating medium, the size of test sample is 50 mm × 50 mm × t, t is generally 4 mm, and minimum product thickness may also be adopted.

CHAPTER 3 FIBER-REINFORCED PLASTIC HULL MATERIALS

Section 1 GENERAL PROVISIONS

3.1.3.3 Approval test of molding procedures for fiber-reinforced plastic craft:

(1) Prior to the commencement of construction of fiber reinforced plastic craft where a new construction technology or a new laminating method or new resins and reinforced materials will be used, the manufacturer is to provide a test specimen laid up by operators in accordance with the procedure specification submitted for approval under the same condition as that of the molding workshop, for verification of fiber reinforced plastic hull design. The thickness of the specimen is to be the smallest thickness of the hull.

(2) The surface of the specimen is to be smooth, even and free from defects such as porosity, lamination, naked fiber, etc.

(3) Laminated plate specimens are to be prepared in accordance with the relevant accepted standards for mechanical tests such as tensile test, compression test, bending test, etc. The density (complying with limit values specified by the manufacturer), Barcol hardness, ~~resin~~-fiber content of the specimen are also to be measured.

(4) Shearing test is to be carried out for sandwich panel specimen in accordance with the relevant accepted standards, and the shear strength is not to be less than 1.33 times that of core material. In addition, a laminate specimen of sandwich panel plate is to be prepared for other tests. The test requirements, methods and results are to be the same as those for the laminated plate specimen.

(5) For hull using glass fiber as reinforcing material, the results of the above-mentioned tests are not to be lower than to comply with the requirements given in Table 3.1.3.3(5); for hull using Aramid fiber or carbon fiber as reinforcing material, the performance tests mentioned above are to be carried out and the test results are not to be lower than the requirements of the strength calculation, with interlaminar shear strength not to be less than 17MPa, and are to be submitted to the Surveyor for confirmation.

(6) The laminated plate moulded by laying up chopped strand mat (CSM) and BIAxIAL woven rovings alternately is recommended.

Mechanical Properties of Test Specimen Table 3.1.3.3(5)

Items	Standard	CSM & BLAXIAL / BLAXIAL type complex mat / CSM & BLAXIAL type complex mat
Tensile strength (N/mm ²)	ISO 527-4	800 G ² - 80 G + 37
Tensile modulus (N/mm ²)	ISO 527-4	38000 G - 5000
Bending strength (N/mm ²)	ISO 14125	502 G ² + 107
Flexural modulus (N/mm ²)	ISO 14125	38000G-6500
Compressive strength (N/mm ²)	ISO 604	150 G + 72
Compressive modulus (N/mm ²)	ISO 604	7000
Interlaminar shear strength (N/mm ²)	ISO 14130	23.2-17.5 G glass fiber ≥ 20 carbon fiber and aramid fiber ≥ 17
Glass -Fiber content (% , by mass)	ISO 1172 (glass fiber) ASTM D3171(carbon fiber / aramid fiber)	G
Barcol hardness	ASTM D2583	40

Notes: ① Tensile and compressive properties in the Table mean in-plane properties, and out-plane compression are not to be used instead of in-plane property test.

② In the Table, G is total nominal glass fiber content and is to be rounded to one digit after the decimal point. The calculation formula can be the calculation formula for G in 2.2.3.4(4). The formula for complex mat in 2.2.3.4(4) may be used as simplified formula, i.e. the laminate is simplified as a big complex mat, and mat and cloth are calculated respectively. If the laminating structure includes complex mat, the complex mat may be simplified as separate mat and cloth for calculation.

Section 3 LAMINATING PROCEDURE

3.3.2.2 Test panels are to be laid up while laminating is proceeding. Test panels may be taken from hull openings or hull extensions. Where this is impracticable, test panels are to be simulated by ordinary operators using a plate mould placed at an angle of about 45°, with the same environmental conditions, raw materials, mixing ratio and process techniques (except for gel coat) as in actual production. Specimens are to be taken in the as-cured condition and their properties tested in accordance with the requirements in 3.4.3.5 with the results in compliance with the requirements in 3.4.3.6. For small craft produced in batches according to the same type as shown in drawings, the same procedure specification and the same production conditions, one specimen is permitted for 10 craft.

3.3.8.5 Excessive exothermic heat generation caused by thick laminate construction is to be

avoided. Where thick laminates are to be laid, ~~it is to demonstrate that the number of plies can be laid wet on wet and that the resultant temperature during the cure cycle does not have any deleterious effect on the mechanical properties of the cured laminate.~~ the design thickness of the laminate is normally not to be more than 10 mm and laminates exceeding this thickness are to be given secondary bonding.

3.3.9.11 Joints in core materials are to be scarped and bonded or connected by similar effective means, and where the thickness of adjacent core materials is different, the width of such transition area is to be at least 3 times the difference in thickness.

3.4.3.5 Tests associated with the laminate properties are to be carried out for the following items ~~by recognized test methods:~~

- (1) fibre content (Glass fibre: ISO1172; carbon fiber/aramid fiber: ASTM D3171);
- (2) tensile strength and modulus (ISO 527-4);
- (3) flexural strength and modulus (ISO 14125);
- (4) compressive strength and modulus (ISO 604);
- (5) shear strength and modulus (ISO14129);
- (6) interlaminar shear strength (ISO14130);
- (7) shear strength and modulus of core material (ISO1922);
- (8) flat wise tensile test of core to skin bondline (ASTM C297).

Section 5 MATERIAL PROPERTIES USED FOR DIRECT CALCULATIONS OF FIBER-REINFORCED PLASTIC CRAFT

3.5.4.3 The performance of one ply materials above is recommended to be obtained by testing methods as follows:

Item	Testing method
Tensile strength and modulus	ISO 527-4,ISO 527-5
Compressive strength	ISO 14126
<u>In-plane</u> shear strength and modulus	<u>ISO 14130-ISO14129</u>

CHAPTER 7 FIBER ROPES

Section 1 MARINE FIBER ROPES

7.1.1 General requirements

7.1.1.2 The materials, ~~and~~ constructions, linear density and rated breaking strength of marine fiber ropes are to comply with the relevant recognized standards.

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 ~~quenched and~~

~~tempered~~ steel used for welding structures with a yield strength of 420 N/mm² and above, a hydrogen test is to be carried out in accordance with 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 with the method approved by CCS, and the test results are to satisfy the requirements of Table 2.3.6.36 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.

CHAPTER 4 QUALIFICATION TESTS OF WELDERS

Section 1 GENERAL PROVISIONS

4.1.1 Application

4.1.1.1 The requirements of this Chapter apply to the qualification tests of welders intended to be engaged in the fusion welding involved in manual (including shielded metal arc welding, semi-automatic welding and TIG welding) of ship structures, offshore structures, machinery, boilers and pressure vessels as well as piping with carbon steels, carbon-manganese steels, alloy steels or aluminum alloys as the base metal.^{Notes}

4.1.1.2 The requirements of this Chapter do not apply to welders engaged in oxy-acetylene welding.

4.1.1.23 For base metals, welding consumables and welding processes other than those specified in this Chapter, the requirements for the qualification tests of welders are to be submitted to CCS for approval.

4.1.1.34 The method of qualification tests of welders engaged in special product welding is to be specially considered by CCS.

4.1.1.5 The welding operator responsible for setting up and/or adjustment of fully mechanized and automatic equipment, such as submerged arc welding, gravity welding, electro-gas welding and MAG welding with auto-carriage, etc., must 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.

For the qualification test and approval range of the welding operator, refer to ISO 14732.

Notes: ① The requirements of this Chapter apply to applications for welder or welding operator qualification (initial or renewal) dated on or after 1 January 2018.

② The requirements of this Chapter do not invalidate welder's qualifications issued and accepted by CCS before 1 January 2018. These qualifications are to be renewed in accordance with the requirements of this Chapter latest by 31 December 2020.

③ Certificates that expire after 1 January 2018 are to be renewed in accordance with the requirements of this Chapter.

④ The welder's or welding operator's qualifications which have not been required before 1 January 2018, are to be initially issued in accordance with the requirements of this Chapter by the 31 December 2020 at the latest.

4.1.2 General requirements

4.1.2.1 Those welders intended to be engaged in welding specified in 4.1.1.1 above in shipyards and manufacturers are to be tested and qualified in accordance with the requirements of this Chapter and issued with a qualification certificate endorsed by CCS.

4.1.2.32 The requirements of this Chapter are applicable to welding of hull structures both during new construction and the repair of ships.

4.1.2.43 The training of welders, control of their qualification and maintenance of their skills are the responsibility of shipyards and manufacturers. The Surveyor is to verify and be satisfied that the welders are appropriately qualified.

4.1.2.54 Welders or welding operators qualified in accordance with national or international welder qualification standards may also be engaged in welding of hull structures and relevant products at the discretion of CCS provided that the qualification testing, range of approval and revalidation requirements are considered equivalent to the requirements of this Chapter.

~~4.1.2 Qualification Test Committee~~

~~4.1.2.45 A Qualification Test Committee may be individually or jointly set up by manufacturers/training providers concerned to take the responsibilities for carrying out the qualification tests in compliance with the requirements of this Chapter.~~

~~4.1.2.2 The Qualification Test Committee, which is to be approved by CCS, is in general to consist of a technical manager, welding engineers or technicians, welding quality inspectors, and experienced welders of the manufacturer.~~

4.1.3 Requirements for test applicants

4.1.3.1 Applicants satisfying one of the following requirements may submit an application to the Qualification Test Committee and take part in the tests upon approval:

(1) holding a graduation certificate of welder training of a technical school and being engaged in welding work;

(2) being capable of welding independently with adequate skill and being engaged in welding work;

(3) having been trained in basic knowledge and operational skill;

(4) additionally for applicants for qualification tests of underwater welders: holding a valid diver's certificate or a graduation certificate of a diving school and possessing a certain skill in underwater welding, ~~or being a diver trained in underwater welding and approved by the Qualification Test Committee.~~

~~4.1.3.2 The requirements for welders applying for upgrading are as follows:~~

~~(1) In general, the applicant is to take part in the tests grade by grade. In special cases, if agreed by the Qualification Test Committee and approved by the attending Surveyor, the applicant may apply for the test of an appropriate grade according to his/her actual working range and operational skill.~~

~~(2) Except for underwater welders, only welders who have more than 6 months' actual working experience of one grade can apply for the test of upgrading to the next higher grade. Those applying for Grade III need to hold a Grade II certificate and have a continuous working experience of more than 1 year for this grade.~~

~~(3) For underwater welders, only those who hold a certificate of one grade and have a continuous working experience of more than 1 year for this grade can apply for the test of upgrading to the next higher grade.~~

4.1.3.3 Applicants engaged in welding are to apply for the tests of an appropriate category according to the requirements specified in this Chapter. Corresponding qualification certificates will be issued by CCS to those who have passed the tests.

4.1.4 Categorization of welder's qualification grades and qualification test items

4.1.4.1 According to types of products, welders are categorized as those qualified for the welding of ships and offshore structures (S) and those qualified for the welding of marine boilers and pressure vessels (B). And according to different welding positions, the qualification grades of welders are categorized as Grades I, II and III for the welding of plates and Grades I_p, II_p, III_p and III_{PR} for the welding of pipes. Grade T means underwater wet tack welding.

4.1.4.2 The welding positions expressed by the codes of test items for different types of test assemblies are shown in Table 4.1.4.2 and Figure 4.1.4.2.

4.1.4.3 The test items corresponding to different welder grades are shown in Table 4.1.4.3.

4.1.4.4 For special needs, fillet weld tests may be carried out according to the actual welding position of the product. Welders may choose to have butt weld and/or fillet weld tests according to their actual needs.

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

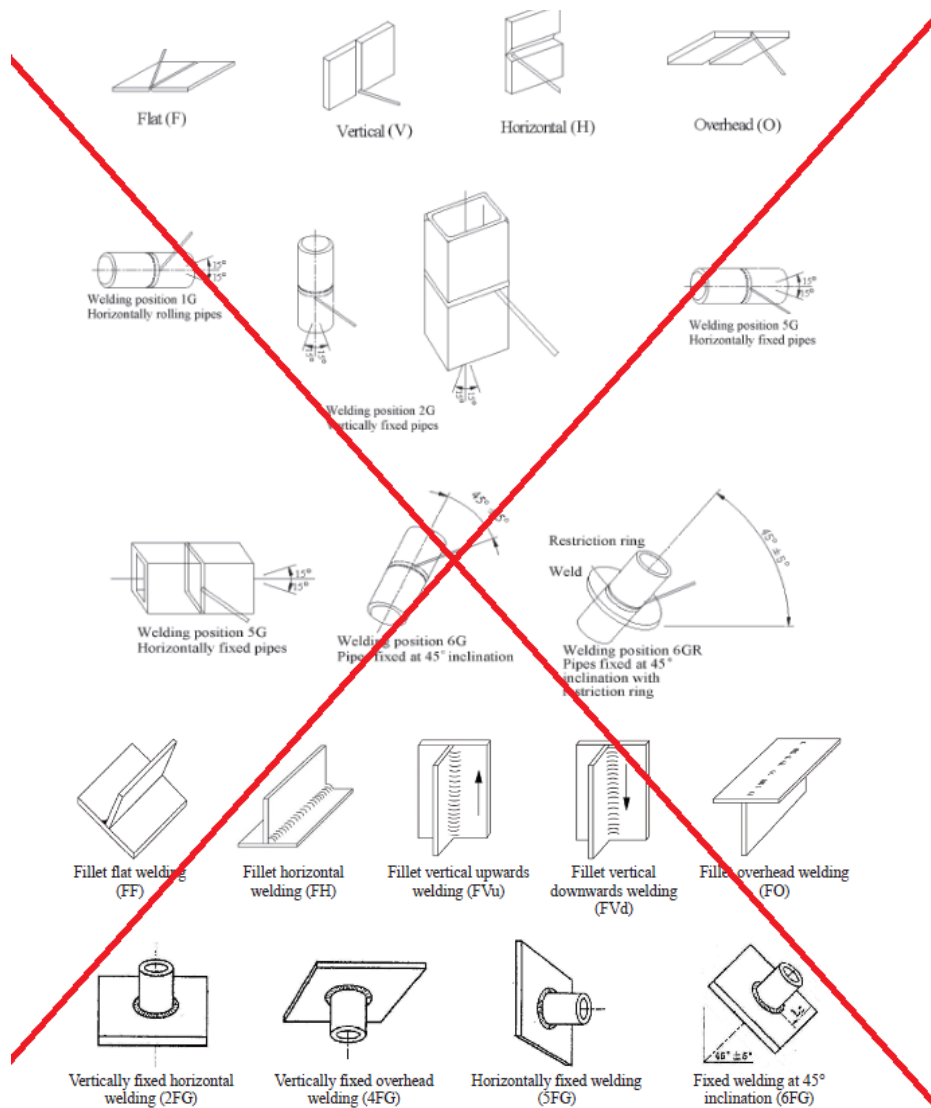


Figure 4.1.4.2—Welding Positions

Test Items for Different Qualification Grades of Welders Table 4.1.4.3

Type of assembly	Grade of welder [Ⓢ]	General test items for qualification of welders	Test items for qualification of underwater welders
Butt welding of plates	I	F	F
	II	H, V	H, V
	III	H, V, O	O
Butt welding of pipes	I _p	1G	2G
	II _p	2G or 5G	5G
	III _p	2G + 5G or 6G	6G
	III _{PR}	6GR	—
Underwater wet tack welding	T	—	F, H, V

Note: ① Qualification grades of welders for different product types are distinguished by letters: “S” for welders engaged in welding of ships and offshore structures, “B” for welders engaged in welding of marine boilers and pressure vessels.

4.1.5 Re-tests and new tests

4.1.5.1 Where the result of any bend or macro specimen is unacceptable in one test item, duplicate specimens for the unsatisfactory item are to be prepared for re-tests. If the results of re-tests are all satisfactory, the test item is considered passed.

4.1.5.2 Where any of the following occurs in one test item, the test item is considered failed and re-tests are not allowed:

- (1) visual examination is not satisfactory;
- (2) radiographic inspection or 2 bend specimens of any butt weld are not satisfactory;
- (3) fracture test or 2 macro specimens of any fillet weld are not satisfactory.

4.1.5.3 Supplementary tests for the failed test item are allowed within a month. The test item is considered passed if the results of all supplementary tests are satisfactory.

4.1.5.4 New tests are allowed only a month later for welders who have failed in all test items. The Qualification Certificate of Welder is to be issued only when all test items are passed. If a welder fails again in the new tests, further tests are not allowed unless the welder is retrained.

4.1.5.5 If the test failure is caused by a poor machined specimen or any defect resulted not from welding, the specimen is to be discarded and a replacement assembly is to be prepared for testing.

4.1.5.1 When a welder fails a qualification test, the following is to apply.

(1) In cases where the welder fails to meet the requirements in part of the tests, a retest may be welded immediately, consisting of another test assembly of each type of welded joint and position that the welder failed. In this case, the test is to be done for duplicate test specimens of each failed test. All retest specimens are to meet all of the specified requirements.

(2) In cases where the welder fails to meet the requirements in all parts of the required tests or in the retest prescribed in 4.1.5.1(1), the welder is to undertake further training and practice.

4.1.5.2 When there is specific reason to question the welder’s ability or the period of effectiveness has lapsed, the welder is to be re-qualified in accordance with the tests specified in Section 2 of this Chapter.

4.1.5.3 Where any test specimen does not comply with dimensional specifications due to poor machining, a replacement test assembly is to be welded and tested.

4.1.6 Certificates

~~4.1.6.1 For welders who have satisfactorily passed a qualification test, a Qualification Certificate of Welder is to be issued by CCS. The welders are to strictly observe the certified range of work as specified in the Certificate. Qualification certificates are normally issued when the welder has passed the qualification test by CCS. Each Shipyard and Manufacturer are to be responsible for the control of the validity of the certificate and the range of the approval.~~

4.1.6.2 The following items are to be included in the Certificate:

- ~~(1) personal information (name, ID number and photograph) of the welder;~~
- ~~(2) name of the work unit where the welder serves;~~
- ~~(3) range of qualification for welding processes, joint types, material and size of base metals, and welding positions as well as water depth for underwater welding;~~
- ~~(4) expiry date of the certificate;~~
- ~~(5) record of six months' supervision by the manufacturer;~~
- ~~(6) record of extension approved by CCS of the period of validity of the certificate.~~

(1) Range of qualification for base metal, welding processes, filler metal type, types of welded joint, plate thicknesses (wall thickness and pipe diameter for pipes) and welding positions as well as water depth (for underwater welding only).

(2) Expiry date of the validity of the qualification.

(3) Name, date of birth, identification and the photograph of the welder.

(4) Name of shipbuilder / manufacturer.

~~4.1.6.3 The Surveyor has the right to check the Qualification Certificate of Welder whenever the welders are engaged in welding. When a certificate is issued, the relative documents such as test reports and/or revalidation records are to be archived as annexes to the copy of certificate.~~

~~4.1.6.4 Each manufacturer is to control the application and validity of the certificate. The status of approvals of each individual qualification is to be demonstrated to CCS when requested.~~

4.1.7 Validity of the qualification

~~4.1.7.1 The Qualification Certificate of Welder is to be valid from the date of issue. Normally the validity of the welder's approval begins from the issue date of qualification certificate when all the required tests are satisfactorily completed.~~

~~4.1.7.2 Except that the Qualification Certificate of Welder for tack welding is valid for an unlimited period, the Qualification Certificate of Welder for various grades is valid for three years from the date of issue (including Grade T wet tack welding), and all the following conditions are to be fulfilled: The certificate is to be signed at six-month intervals by the shipyards/manufacturers personnel who is responsible for production weld quality (e.g. personnel in charge of the quality inspection department) provided that all the following conditions are fulfilled:~~

- ~~(1) the welder is to be engaged with reasonable continuity on welding work within the current range of approval. An interruption for a period no longer than six months is permitted;~~
- ~~(2) the welder's work is in general to be in accordance with the technical conditions under which the approval test is carried out;~~
- ~~(3) there is to be no specific reason to question the welder's skill and/or knowledge.~~

~~4.1.7.3 If any of these conditions are 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.

4.1.7.4 Except that the Qualification Certificate of Welder for tack welding is valid for an unlimited period, revalidation is to be carried out by CCS for the Qualification Certificate of all welders. The skill of the welder is to be periodically verified by one of the following:

(1) The welder is to be tested every 3 years.

(2) Every 2 years, two welds made during the last 6 months of the 2 years validity period are to be tested by radiographic or ultrasonic testing or destructive testing and are to be recorded. The welds tested are to reproduce the initial test conditions except for the thickness. These tests revalidate the welder's qualifications for an additional 2 years.

4.1.7.5 CCS has to verify compliance with the above conditions and sign the maintenance of the welder's qualification certificate.

~~4.1.7.3 If a welder (or tack welder) has not been engaged in welding for 6 consecutive months, he is, prior to being re-engaged in welding, to weld a test assembly in the most difficult position specified in his Qualification Certificate. The welder may be permitted to continue to be engaged in the welding work only upon satisfactory results of the test.~~

~~4.1.7.4 Prior to the expiry date of the Certificate, welders are to take new tests especially for operational skill. With satisfactory results of the new tests, the period of validity of the Certificate may be extended for another 3 years.~~

~~4.1.7.5 If a welder has been proved to be consistently good in welding quality (i.e. more than 90% of his welding products have been found satisfactory by non-destructive testing) within the period of validity of the Certificate and possesses a record of such welding quality which has been checked by the Surveyor, the period of validity of the Certificate may be extended for one year without new tests, subject to his nomination by the Qualification Test Committee and the approval by CCS.~~

Section 2 QUALIFICATION TESTS AND EVALUATION OF WELDERS

4.2.1 General requirements

4.2.1.1 Welding of the test assemblies and testing of test specimens are to be witnessed by the Surveyor. The qualification tests of welders consist of a basic knowledge test and an operational skill test. An applicant is qualified to take the operational skill test only after he has successfully passed the basic knowledge test. Both the test of basic knowledge and that of operational skill are to be carried out under the supervision of the Surveyor.

~~4.2.1.2 The basic knowledge test is to correspond to the welding processes to be applied for the operational skill test and may include the basic knowledge of normal base metals, welding consumables, welding equipment, welding procedures, common types of welding defects, prevention and repair of defects as well as safety of welding. Test questions are to be determined by CCS.~~

~~4.2.1.32 Prior to the operational skill welder qualification test, the Qualification Test Committee is to submit the intended qualification grades of welders welding positions, material groups, thicknesses of test assemblies (pipe diameters), joint types and edge preparation dimensions to CCS for confirmation.~~

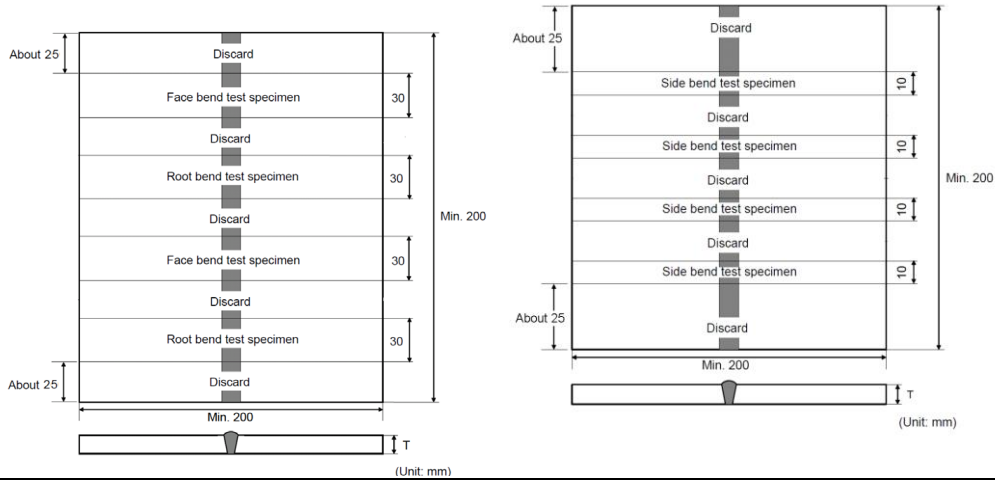
~~4.2.1.43 For the test of operational skill welder qualification, on-site record of the test is to be made by the person in charge of the test and confirmed by the Surveyor. The Test Committee is to complete a summary table of test evaluation and submit it to CCS.~~

~~4.2.1.54 The plates, pipes and welding consumables for the tests are to comply with the relevant requirements specified in PART ONE and Chapter 2 of this PART 4.2.3 of this Chapter. Typical materials are to be selected for the tests.~~

4.2.1.6 For tack welding, one pair of test plates is to be welded for each position on which the welder will be engaged.

4.2.2 Type and dimensions of test assemblies

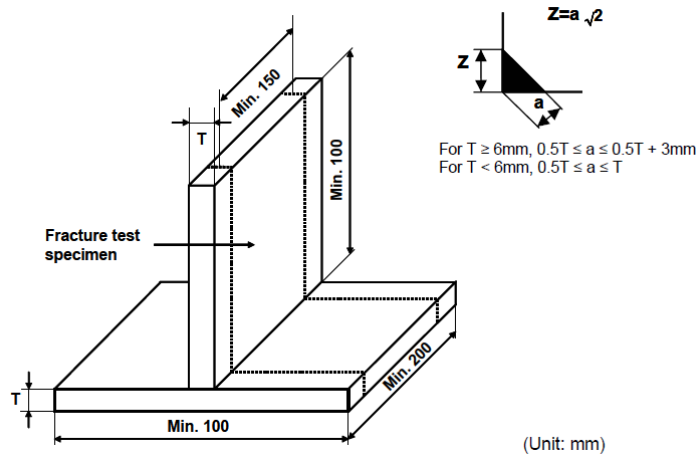
4.2.2.1 Dimensions for butt and fillet welds in plates, butt welds in pipes and pipe-to-plate fillet welds are shown in Figures 4.32.2.1(a), (b), (c) and (d) respectively.



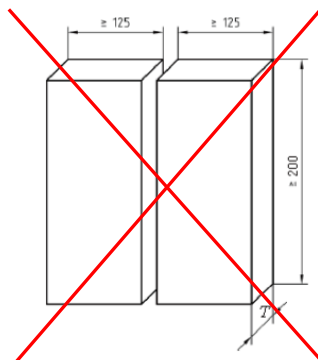
$T < 12 \text{ mm}$

$T \geq 12 \text{ mm}$

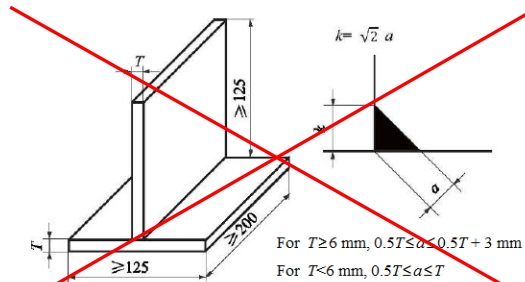
(a) Butt welds



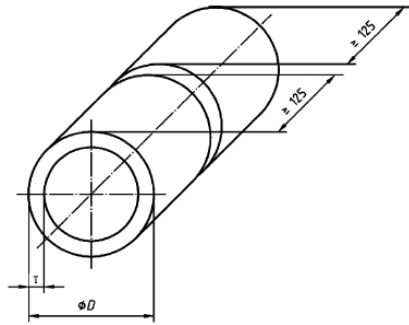
(b) Fillet welds



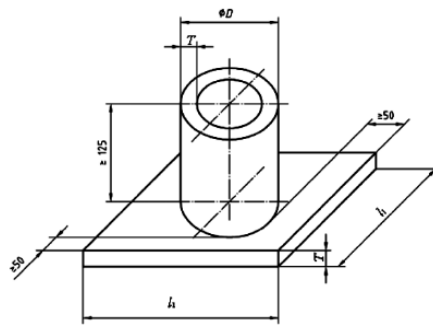
(a) Butt welds in plates



(b) Fillet welds in plates



(c) Butt welds in pipes



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

Figure 4.2.2.1 Dimensions of Test Assemblies

4.2.2.2 For butt welds in pipes, a minimum examination length of 150 mm is required. If the circumference of pipes is less than 150 mm, additional test assemblies are to be required.

4.2.2.3 Specific types of butt welded joints (both sides, one side, with or without backing) and dimensions of edge preparation (included angle, root face, gap) may be determined by the manufacturer according to the actual production.

4.2.2.4 Special requirements for dimensions of the butt welded pipe assembly in the 6GR position are shown in Figure 4.2.2.4.

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

4.2.2.6 Fillet welding is to be adopted for plates, and the throat thickness is shown in Figure 4.2.2.1(b).

~~4.2.2.7 Dimensions and tacking requirements of tack welding are shown in Figure 4.2.2.7. Dimensions of test assemblies for tack butt welds and tack fillet welds are shown in Figures 4.2.2.7(a) and (b) respectively.~~

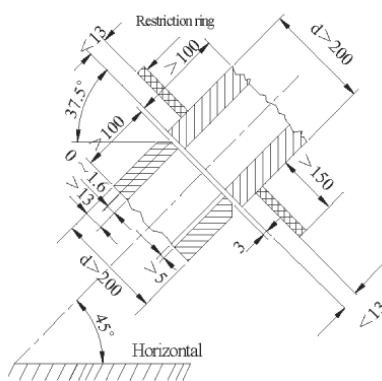


Figure 4.2.2.4

Dimensions of butt welded pipe assembly in the 6GR position

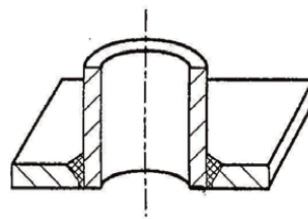


Figure 4.2.2.5

Pipe-to-plate fillet welds

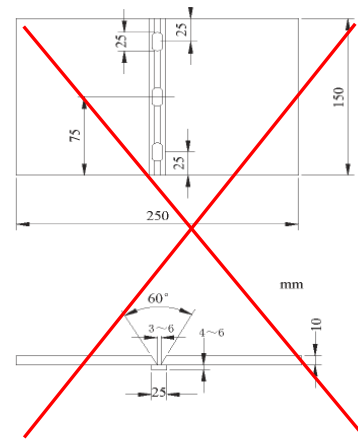


Figure 4.2.2.7

~~Dimensions and tacking requirements for tack welding~~

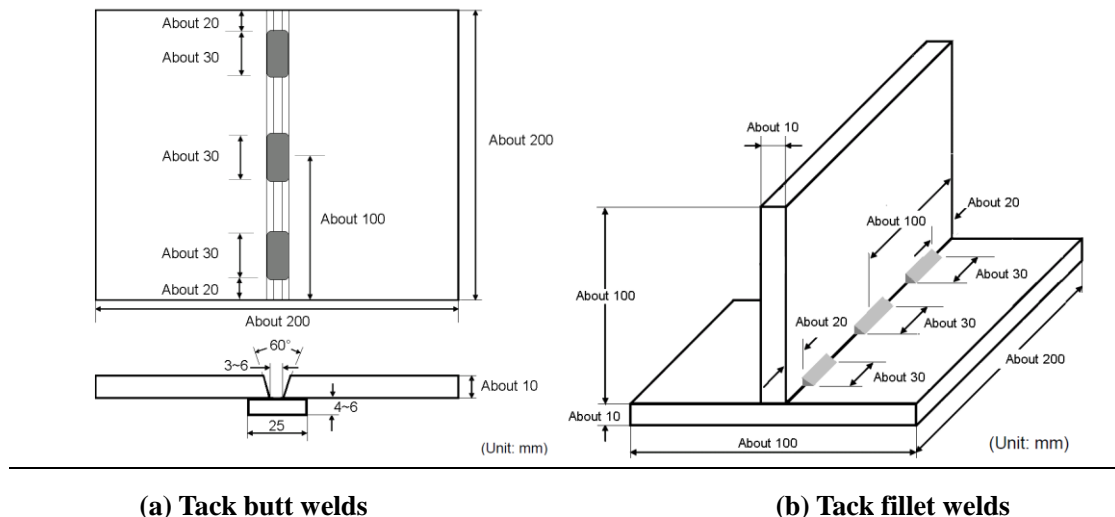


Figure 4.2.2.7 Dimensions of test assemblies for tack butt welds and tack fillet welds

4.2.3 Preparation of test assemblies

4.2.3.1 Testing materials are to comply with the relevant provisions of PART ONE of the Rules. Hull structural steels are to conform to one of the following requirements or to be of equivalent grade approved by CCS:

- (1) Hull structural steels specified in Sections 2 and 3, Chapter 3, PART ONE of the Rules;
- (2) Hull structural forged steels specified in Section 2, Chapter 5, PART ONE of the Rules;
- (3) Hull structural cast steels specified in Section 2, Chapter 6, PART ONE of the Rules;
- (4) Hull structural steels with specified minimum yield point 460 N/mm^2 specified in CCS Guidelines for Inspection of Thick Higher Strength Steel Plates for Ships.

4.2.3.2 Welding consumables are to match testing materials in performance. Welding consumables for hull structural steels are to conform to one of the following requirements:

- (1) Consumables for hull structural steels specified in Sections 1 to 7, Chapter 2 of this PART;
- (2) Consumables for H47 steels specified in CCS Guidelines for Inspection of Thick Higher Strength Steel Plates for Ships.

4.2.3.43 The welder qualification test assembly is to be edge prepared, joined, cleaned prior to welding and welded according to a welding procedure specification (WPS or pWPS) simulating the conditions in production, as far as practicable. The test assembly is to be welded according to the welding procedure used for products. Welding parameters are to comply with the requirements of WPS.

4.2.3.32 Edge preparation, joining and cleaning prior to welding are to be carried out as required.

4.2.3.34 Each test assembly is to be stamped with the identification number of the welder and the mark of the welding position, and the stamps are to be kept throughout the test. Welding positions for pipes fixed horizontally or at 45° inclination to the horizon are to be expressed by clock hours.

4.2.3.4 Run on and run off tabs are not to be fitted on the ends of the groove.

4.2.3.5 Once welding is started, the welding position of the test assembly is not to be changed or altered. The welding direction is to be kept consistent throughout the operation.

4.2.3.6 Root run and capping run need each to have a minimum of one stop and restart. The welders are allowed to remove minor imperfections only in the stop by grinding before restart

welding. The test assemblies are to have at least one stop and one re-start in the capping run. For the test of one-side welding with back formation, one stop and one re-start are to be additionally available in the root run.

4.2.3.7 For materials or procedures requiring preheating, postheating or heat input control, the welding conditions are to be the same as those required for products (post-weld heat treatment or ageing may be omitted unless bend tests are required).

4.2.3.87 On completion of welding, there is to be no grinding or repairs on the surface of the weld.

4.2.4 Test or inspection

4.2.4.1 Test or inspection items and required specimens for different types of test assemblies are shown in Table 4.2.4.1.

Test and Inspection Items Table 4.2.4.1

Type of assembly	Test or inspection items ^①
Butt welding of plates	1. Visual inspection 2. Bend test ^{①②}
Butt welding of pipes	1. Visual inspection 2. Bend test ^{①②}
Fillet welding of plates	1. Visual inspection 2. Fracture test or macro examination ^③
Pipe-to-plate fillet welds	1. Visual inspection 2. Macro examination
Tack welding	1. Visual inspection 2. Fracture test

- Notes: ① Radiographic test or fracture test may be carried out in lieu of bend test except the gas-shielded welding processes with solid wire or metal cored wire and aluminum alloy welding.
 ② Radiographic inspection + bend test for welders engaged in welding of marine boilers and pressure vessels.
 ③ Two macro sections may be taken in lieu of the fracture test.
 ④ Additional tests may be required, at the discretion of CCS.

Test or Inspection Items and Required Specimens Table 4.2.4.1

Type of assembly	Test or inspection items	Required specimens
Butt welding of plates	Visual inspection Bend test and/or radiographic inspection ^{①②}	Visual inspection: weld length Radiographic inspection: examination length of weld ^③ Bend: one for face bend test and one for root bend test ^④
Butt welding of pipes	Visual inspection Bend test and/or radiographic inspection ^{①②}	Visual inspection and radiographic inspection: weld length Bend: one for face bend test and one for root bend test ^④ – at 1G and 2G; two for face bend test and two for root bend test ^④ – at 5G, 6G and 6GR
Fillet welding of plates	Visual inspection Fracture test or macro examination	Visual inspection: weld length Fracture: examination length of weld ^③ Macro: two
Pipe to plate fillet welds	Visual inspection Macro examination	Visual inspection: weld length Macro: two
Tack welding	Visual inspection Bend test	Visual inspection: all welding points Bend: the specimen is bent with backing strap in place and with face of the welds in tension

- Notes: ① Bend test cannot be omitted for solid wire gas shielded welding (including aluminum alloy).
 ② Radiographic inspection + bend test for welders engaged in welding of marine boilers and pressure vessels.
 ③ The examination length of weld is the length deducted by 25 mm from both ends of the test assembly respectively.
 ④

- ~~④ If the thickness of the test assembly is not less than 12 mm, side bends may be used instead.~~
- ~~4.2.4.2 For visual inspection, the surface of welds is to be in the as welded state and no machining is to be made.~~
- ~~4.2.4.3 For radiographic inspection, the reinforcement of welds and backing may not be removed.~~
- ~~4.2.4.4 Specimens are generally taken by machining in order not to affect the properties of the material. If flame cutting is applied, surplus metal not less than 5 mm from the line of cut is to be kept on both sides for machining.~~
- ~~4.2.4.5 For bend test, the reinforcement of welds and backing (if any) are to be machined flush with the rolled surface of the base metal. Undercut is not to be removed. Bend test specimens are to be taken as shown in Figures 4.2.4.5(a) and (b). The dimensions of and requirements for specimens are shown in Figures 1.2.3.3 and 1.2.3.4 of Chapter 1 of this PART.~~
- ~~4.2.4.6 For pipe to plate fillet welds, the test assembly is to be cut by mechanical means into four equal parts as shown in Figure 4.2.4.6, from which two parts are to be selected for macro examination of sections A and B (B being the stop/start location).~~
- ~~4.2.4.7 For the fracture test of fillet welds in plates, the test method is given in 1.2.4.4 of Chapter 1 of this PART.~~
- ~~4.2.4.8 For the macro examination of fillet welds in plates, one of the macro sections is to be taken at the stop/start location.~~

4.2.5 Evaluation of test assemblies

4.2.4.2 The welds are to be visually examined prior to the cutting of the test specimen for the bend test and fracture test. Visual examination is to comply with the following requirements:

(1) The surface of welds is to be in the as-welded state and no machining is to be made. The result of the examination is to show the absence of cracks or other serious imperfections.

(2) Imperfections detected for steel and aluminum alloy welds are to be assessed respectively in accordance with the requirements for level B of ISO 5817 and ISO 10042 (excess weld metal, excess penetration, excessive convexity and excessive throat thickness for which level C applies), and the acceptance standards for main items are given in Table 4.2.4.2.

~~4.2.5.1 The visual inspection of steel and aluminum alloy welds is to be respectively in accordance with the requirements for level B of ISO 5817 and ISO 10042 (excess weld metal, excessive convexity and excess penetration for which level C applies), and the acceptance standards for main items are given in Table 4.2.5.1.~~

Acceptance Standards for Visual Inspection of Welds Table 4.2.54.12

Name of defect	Acceptance standards	
	Steel	Aluminum alloy
Crack	Not allowed	Not allowed
Lack of fusion	Not allowed	Not allowed
Root with incomplete penetration	Not allowed	Not allowed
Surface overlap	Not allowed	Not allowed
Surface pore	Not allowed	Concentrated pore and chain pore are not allowed; uniformly distributed porosity rate $\leq 0.5\%$, single pore diameter $\leq 0.2t$ ^① , maximum 1 mm
Local root depression	Depth $\leq 0.05t$ ^① , maximum 0.5 mm	Depth $\leq 0.05t$ ^① , maximum 0.5 mm
Undercut	Depth $\leq 0.05t$ ^① , maximum 0.5 mm	Depth $\leq 0.1t$ ^① , maximum 0.5 mm (continuous undercuts are not allowed)
Excess weld metal (butt weld)	Height $\leq 1+0.15b$ ^② , maximum 7.0 mm	Height $\leq 1+0.15b$ ^② , maximum 8.0 mm
Excessive convexity (fillet	Height $\leq 1+0.15b$ ^② , maximum 4.0	Height $\leq 1.5+0.15b$ ^② , maximum 4.0 mm

weld)	mm	
Excess penetration	Height $\leq 1+0.6b^{②}$, maximum 4.0 mm	Height ≤ 4.0 mm
Excessive throat thickness	Height $\leq 1+0.2a^{③}$, maximum 4.0 mm	==
Insufficient throat thickness	Not allowed	Height $\leq 0.1a^{③}$
Unsymmetrical fillet weld leg	Difference of weld leg length $\leq 1.5+0.15a^{③}$	Difference of weld leg length $\leq 1.5+0.2a^{③}$

Notes: ① t —plate thickness for butt weld and throat thickness for fillet weld, in mm;
 ② b —corresponding weld breadth (root weld breadth for excess penetration), in mm;
 ③ a —throat thickness, in mm.

4.2.54.23 The bend test for butt welding is to comply with the following requirements:

(1) See Figures 1.2.3.3 and 1.2.3.4, Chapter 1 of this PART for the dimensions of and requirements for transverse bend test specimens.

(2) The diameter of the former and the angle of bend are to comply with the requirements for welding procedure approval tests in 1.2.4.2 of Chapter 1 of this PART.

(3) For butt weld joints of plates, two face bend test and two root bend test specimens are to be tested for initial qualification test, and one face and one root bend test specimens for extension of approval. For thickness 12 mm and over, four side specimens (two side specimens for extension of approval) with 10 mm in thickness may be tested as an alternative. See Figure 4.2.2.1(a) of this Section for the sampling location of the bend specimen for initial qualification test.

(4) For butt weld joints of pipes, the requirements of test positions at 1G and 2G are the same as those specified in (3) above, however, regardless of initial qualification test or retest, four bend tests are to be carried out for the welders at 5G, 6G and 6GR. The sampling positions for bend specimen are shown in Fig. 4.2.4.3(a) and (b).

(5) At least one bend test specimen is to include one stop and restart in the bending part, for root run or for cap run.

(6) The test specimens are to be bent through 180 degrees. After the test, the test specimens are not to reveal any open defects in any direction greater than 3 mm. Defects appearing at the corners of a test specimen during testing are to be investigated case by case. After testing, the test specimens are not to reveal any crack or other open defect in any direction greater than 3 mm on the surface in tension.

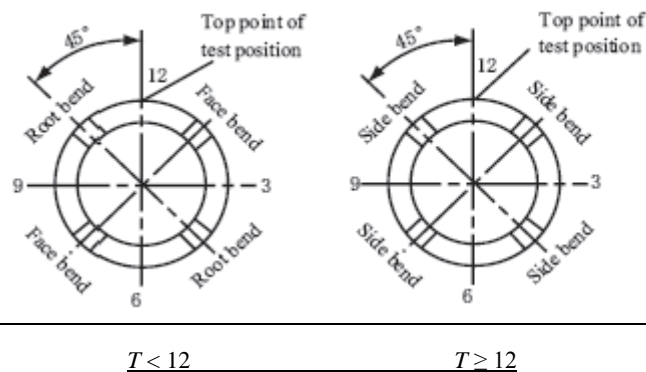


Figure 4.2.4.3(a) Sampling Position of Bend Test Specimen for Butt Weld Joints of Pipes (Initial Qualification Test)

$T < 12$ ————— $T \geq 12$

(a) Test assembly of plates

1G, 2G ($T < 12$)

5G, 6G, 6GR ($T < 12$)

1G, 2G ($T \geq 12$)

5G, 6G, 6GR ($T \geq 12$)

(b) Test assembly of pipes

Figure 4.2.4.53(b) Sampling Positions of Bend Test Specimens for Butt Weld Joints of Pipes (Re-qualification Test)

4.2.54.34 For steels and aluminum alloys, when radiographic testing is used for butt welds, imperfections detected are to be assessed in accordance with the results of the radiographic examination of butt welds are to comply with the requirements for level B of ISO 5817 and ISO 10042 respectively or other equivalent standards.

4.2.4.5 When fracture test is used for butt welds, full test specimen in length is to be tested in accordance with ISO 9017. Imperfections detected for steel and aluminum alloy welds are to be assessed in accordance with level B of ISO 5817 and ISO10042 respectively.

4.2.54.46 When fracture test is used for butt welds, the test method is to be in accordance with 1.2.4.4, Chapter 1 of this PART. Evaluation is to concentrate on cracks, porosity and pores, inclusions, lack of fusion and incomplete penetration. Imperfections detected are to be assessed in accordance with The fractured surfaces of fracture test specimens (for fillet welds in plates) are to show welds without cracks and lack of fusion, with slag inclusions and pores complying with the requirements for level B of ISO 5817 or and ISO 10042 respectively or other equivalent standards.

4.2.54.57 When macro examination is used for fillet welds, two test specimens are to be prepared from different cutting positions; at least one macro examination specimen is to be cut at the position of one stop and restart in either root run or cap run. Prepare the specimens according to 1.2.3.7, Chapter 1 of this PART. These specimens are to be etched on one side to clearly reveal the weld metal, fusion line, root penetration and the heat affected zone. Macro sections are to include at least 10mm of unaffected base metal. The examination is to reveal a regular weld profile, through fusion between adjacent layers of weld and base metal, sufficient root penetration and the absence of defects such as cracks, lack of fusion etc. The macro examination for fillet welds in plates and pipe to plate fillet welds is to reveal a regular weld profile, sufficient root penetration (full root penetration of pipe to plate fillet welds) and the absence of defects such as cracks, lack of fusion, etc.

4.2.4.68 For pipe-to-plate fillet welds, the test assembly is to be cut by mechanical means into four equal parts as shown in Figure 4.2.4.68, from which two parts are to be selected for macro-examination of sections A and B (B being the stop/start location). The specimens are to be prepared and etched as per 4.2.4.7. The examination of macro sections is to reveal a regular weld profile, full root penetration and the absence of defects such as cracks, lack of fusion etc.

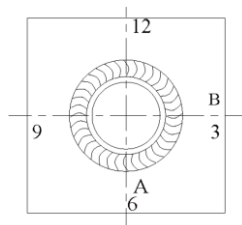


Figure 4.2.4.68 Cutting Position of Macro Sections of Pipe-to-Plate Assembly

4.2.54.69 After bend fracture testing of tack weld specimens, weld fractures throughout the length of each tack are to show neither lack of fusion on the backing strap or both sides of the groove nor slag inclusions or pores exceeding 2 mm.

Section 3 SCOPE OF APPLICATION OF WELDER'S QUALIFICATION

4.3.1 General requirements

4.3.1.1 A welder is to be qualified in relation to the following variables of welding: The welder's qualification approval applies to not only items with the same welding conditions, but also items of which the essential variables are within the specified range. The essential variables include welding processes, joint types, properties and specifications of base metals, plate thickness (wall thickness and pipe diameter for pipes), welding consumables type and welding positions.

4.3.1.2 A grade of qualification for welders engaged in the welding of boilers and pressure vessels covers the same grade of qualification for welders engaged in the welding of ships and offshore structures. Welders who passed the qualification test for welding boilers and pressure vessels can be deemed as qualified for welding ships and offshore structures when the welding variables above are same.

4.3.1.3 Welders of any grade may be deemed as qualified for tack welding.

4.3.2 Welding processes

4.3.2.1 The welding processes for welder's qualification are to be classified in Table 4.3.2.1. Each testing normally qualifies only for one welding process. A change of welding process requires a new qualification test.

Welding processes for welder's qualification Table 4.3.2.1

Symbol	Welding process in actual welding works		ISO 4063
M	Manual welding		111
S	Semi-automatic welding/Partly mechanized welding	Shielded metal arc welding (SMAW)	111
		Metal inert gas (MIG) welding	131
		Metal active gas (MAG) welding Flux cored arc (FCA) welding	135, 138 ^① 136 ^②
T	TIG welding	Tungsten inert gas (TIG) welding	141

Notes: Qualification for solid wires, metal cored wires and flux cored wires are as follows:

- ① A change from MAG welding with solid wires (135) to that with metal cored wires (138), or vice versa is permitted.
- ② A change from a solid or metal cored wire (135/138) to a flux cored wire (136) or vice versa requires a new welder qualification test.

4.3.2.1 The welding processes applicable to welders' qualifications are divided into 3 categories in Table 4.3.2.1. The individual qualifications for welding processes of different categories cannot cover each other.

Categories of Welding Processes Table 4.3.2.1

Category		Welding process
Metal arc welding		Metal arc welding
Gas metal arc welding [⊕]	Group 1	Self shielded arc welding with flux cored wires Metal active gas (MAG) welding with flux cored wires Metal inert gas (MIG) welding with flux cored wires
	Group 2	Metal active gas (MAG) welding with solid wires Metal inert gas (MIG) welding with solid wires
Non consumable electrode gas shielded arc welding		Tungsten inert gas (TIG) welding

Note: ① In gas metal arc welding, the welding process of group 2 can cover that of group 1.

4.3.2.2 It is permitted for a welder to be qualified for two welding processes, e.g. root run with TIG welding, which are combined by welding a single test piece, applicable to single side welding by root run and double side welding by capping run respectively. The scope of application of thickness is appropriate to the weld thickness.

4.3.3 Types of welds

4.3.3.1 The types of welded joint for welder's qualification are to be classified as shown in Table 4.3.3.1 in accordance with the qualification test.

Types of welded joint for welder's qualification Table 4.3.3.1

Type of welded joint used in the test assembly for the qualification test			Type of welded joint qualified	
Butt weld	Single sided weld	With backing	A	A, C, F
		Without backing	B	A, B, C, D, F
	Double sided weld	With gouging	C	A, C, F
		Without gouging	D	A, C, D, F
Fillet weld	---	E	F	

Note: Welders engaged in full/partial penetration T welds are to be qualified for butt welds for the welding process and the position corresponding to the joints to be welded.

4.3.3.1 The range of qualification for weld details on butt welds is shown in Table 4.3.3.1.

Range of Qualification for Weld Details on Butt Welds Table 4.3.3.1

Type of weld used in the test assembly for the qualification test		Range of qualification			
		Single side welding		Double side welding	
		With backing	Without backing	With gouging	Without gouging
Single side welding	With backing	*	—	×	—
	Without backing	×	*	×	×
Double side welding	With gouging	×	—	*	—
	Without gouging	×	—	×	*

Key: * indicates the weld for which the welder is approved in the qualification test.

— indicates those welds for which the welder is also qualified.

× indicates those welds for which the welder is not qualified.

4.3.3.2 For fillet welding, welders who passed the qualification tests for multi-layer technique welding can be deemed as qualified for single layer technique, but not vice versa.

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

4.3.3.34 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.

4.3.3.4 Butt welds cover fillet welds (including full penetration fillet welds, partial penetration fillet welds or fillet welds) for appropriate welding positions. Butt welds in plates can only cover fillet welds in plates.

4.3.3.5 Fillet welds do not cover full penetration fillet welds.

4.3.4 Parent material

4.3.4.1 Steels are grouped in Table 4.3.4.1. The welding of any one material in a group confers approval on the welder for the welding of all other materials within the same group. The welding of any one metal in this group covers qualification of the welder or welding operator for the welding of all other metals within this group.

Steel Groups Table 4.3.4.1

Material group	Steel type
W01 ^①	Carbon steel/carbon-manganese steel and low-alloy higher tensile steel with yield strength $R_{eH} \leq 390 \text{ N/mm}^2$
W02	CrMo steel and creep-resistant CrMoV steel
W03	Higher tensile steel with yield strength $R_{eH} > 390 \text{ N/mm}^2$, and nickel steel with Ni content < 5% ^②
W04	Ferritic or martensitic stainless steel with Cr content between 12% and 20%
W05	Nickel steel for low temperature service with Ni content $\geq 5\%$

W11	Austenitic or duplex stainless steel
-----	--------------------------------------

Notes: ① Hull structural steels with specified minimum yield point 460 N/mm² specified in CCS Guidelines for Inspection of Thick Higher Strength Steel Plates for Ships may be categorized into W01.

② Except for those included in W01.

4.3.4.2 The range of a welder's qualification for parent metals is shown in Table 4.3.4.2.

Range of Welder's Qualification for Parent Metals Table 4.3.4.2

Material group of test piece ^①	Range of qualification					
	W01	W02	W03	W04	W05	W11
W01	*	–	–	–	–	–
W02	×	*	–	–	–	–
W03	×	×	*	–	–	–
W04	×	×	×	*	–	–
W05	–	–	–	–	*	–
W11	– ^②	– ^②	– ^②	– ^②	–	*

Notes: ① This Table applies only when parent metal indicated by * and filler metal are in the same group, except for W05.

② When using filler metal from group W11.

Key: * indicates the material group for which the welder is approved in the qualification test.

× indicates those material groups for which the welder is also qualified.

– indicates those material groups for which the welder is not qualified.

4.3.4.3 The qualification for welding any type of aluminum alloys in the aluminum-magnesium series (5000 series) or the aluminum-silicon-magnesium series (6000 series) cover all aluminum alloys of both series.

4.3.4.4 When welding with parent or filler materials outside the grouping system in 4.3.4.1 and 4.3.4.3, a separate test is required.

4.3.5 Welding consumables

4.3.5.1 For manual metal arc welding, qualification tests are required using basic, acid or rutile covered electrodes. ~~For shielded metal arc welding, welders who have passed the qualification tests for welding with basic electrodes may be deemed as qualified for welding with acid electrodes, but not vice versa.~~ The qualification for welding with cellulose type electrodes does not cover that for welding with other coated electrodes.

~~4.3.5.2 Welders who have passed the qualification tests for gas metal arc welding with solid wires may be deemed as qualified for that with flux-cored wires.~~

~~4.3.5.3 Welders who have passed the qualification tests for argon-shielded tungsten arc welding with filler material wire or rod may be deemed as qualified for that without filler material wire or rod, but not vice versa.~~

4.3.6 Thickness and pipe diameter

4.3.6.1 For butt and fillet welds in plates and butt welds in pipes, the qualified thickness range for steel and aluminum alloy is shown in Tables 4.3.6.1(a) and 4.3.6.1(b) respectively.

Qualified Thickness Range for Steel Table 4.3.6.1(a)

Thickness of test assembly ^① T (mm)	Qualified thickness range t (mm)
$T \leq 3$	$T \leq t \leq 2T$
$3 < T \leq 20 < 12$	$3 \leq t \leq 2T$
$T > 20 \geq 12$	$t \geq 3$

Note: ① For multi-process procedure, T is the thickness of deposited metal for each welding process.

Qualified Thickness Range for Aluminum Alloy Table 4.3.6.1(b)

Thickness of test assembly ^①	Qualified thickness range
---	---------------------------

T (mm)	t (mm)
$T \leq 6$	$0.5T \leq t \leq 2T$
$T > 6$	$t \geq 6$

Note: ① For multi-process procedure, T is the thickness of deposited metal for each welding process.

4.3.6.2 For butt welds in pipes, the range of qualification for outside pipe diameter is shown in Table 4.3.6.2.

Range of Qualification for Outside Pipe Diameter Table 4.3.6.2

Outside pipe diameter of test assembly D (mm)	Range of qualification d (mm)
$D \leq 25$	$D \leq d \leq 2D$
$D > 25$	$D \geq 0.5D$ (25 minimum)

4.3.6.3 The range of qualification for pipe-to-plate fillet welds is as follows:

(1) The qualified range of plate thicknesses is to be in accordance with Tables 4.3.6.1(a) and Table 4.3.6.1(b), regardless of the thickness of pipe wall.

(2) The qualified range of pipe diameters is shown in Table 4.3.6.2.

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 (Diagrams showing the definitions of weld position used in these Tables are shown in Figure 4.3.7.1 and Table 4.3.7.1d).

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 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

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

Qualified welding positions when testing with fillet welding Table 4.3.7.1b

<u>Qualification Test Position with fillet weld</u>	<u>Qualified welding positions in actual welding works</u>
<u>FF</u>	<u>FF</u>
<u>FH</u>	<u>FF, FH</u>
<u>FHa</u>	<u>FF, FH, FHa</u>
<u>FVd</u>	<u>FVd</u>
<u>FVu</u>	<u>FF, FH, FVu</u>
<u>FO</u>	<u>FF, FH, FHa, FO, FOa</u>
<u>FOa</u>	<u>FF, FH, FHa, FO, FOa</u>

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

<u>Qualification Test Position with butt weld of pipes</u>	<u>Qualified welding positions in actual welding works</u>			
	<u>Butt welding of plates^①</u>	<u>Butt welding of pipes</u>	<u>Fillet welding of plates^①</u>	<u>Pipe-to-plate fillet welding^②</u>
<u>1G</u>	<u>F</u>	<u>1G</u>	<u>FF, FH</u>	<u>=</u>
<u>2G</u>	<u>F, H</u>	<u>1G, 2G</u>	<u>FF, FH, FHa</u>	<u>2FG</u>

5G	F, Vu, O	1G, 5G	FF, FH, FVu, FO, FOa	2FG, 4FG, 5FG
2G+5G	F, H, Vu, O	1G, 2G, 5G, 6G	FF, FH, FHa, FVu, FO, FOa	2FG, 4FG, 5FG, 6FG
6G	F, H, Vu, O	1G, 2G, 5G, 6G	FF, FH, FHa, FVu, FO, FOa	2FG, 4FG, 5FG, 6FG
6GR	F, H, Vu, O	1G, 2G, 5G, 6G	FF, FH, FHa, FVu, FO, FOa	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.

4.3.7.1 The principle for welding positions is that a higher welder grade covers low welder grades.

4.3.7.2 The welding positions for fillet welds in respect to welder qualification grades are shown in Table 4.3.7.2.

Welding positions for fillet welds in respect to welder qualification grades

Table 4.3.7.2

Grade	Range of qualification for fillet welding of plates	Range of qualification for pipe to plate fillet welding ^①
I	FF, FH	=
II	FF, FH, FVu	=
III	FF, FH, FVu, FO	=
I _p	FF, FH	=
II _p	FF, FH ^② FF, FH, FVu, FO ^③	2FG ^② 2FG, 4FG, 5FG ^②
III _p	FF, FH, FVu, FO	2FG, 4FG, 5FG, 6FG
III _{PR}	FF, FH, FVu, FO	2FG, 4FG, 5FG, 6FG

Note: ① Not applicable to pipe to plate fillet welds (insertion) in boilers and pressure vessels.

② For test item 2G.

③ For test item 5G.

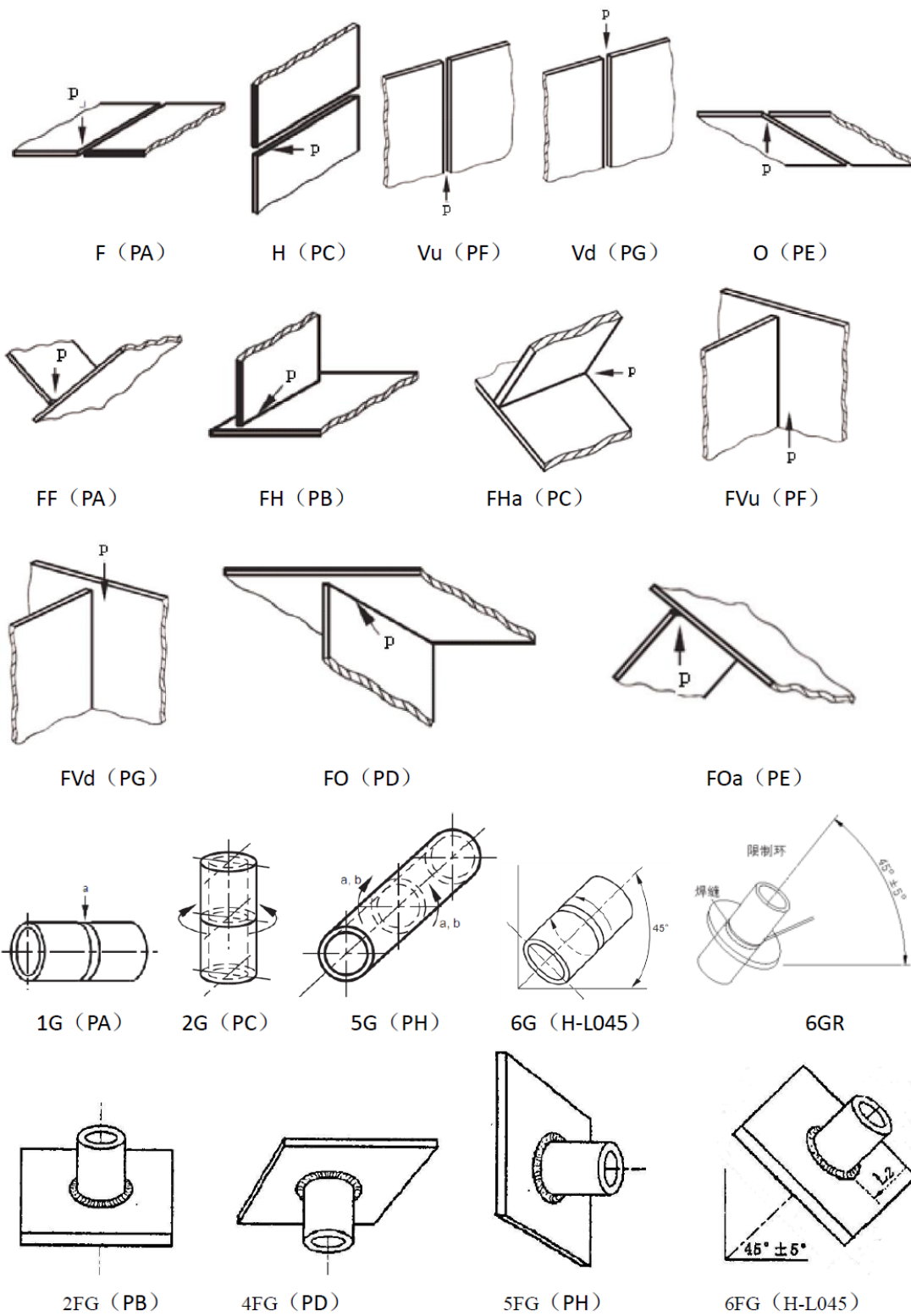


Figure 4.3.7.1 Welding Positions

Code of Test Items-Welding Positions

Table 4.3.7.1d4.1.4.2

Type of assembly	Code of test items-(welding position)	Welding positions	ISO6947 corresponding code
Butt welding	F	Flat (downhand) welding	PA

Type of assembly	Code of test items- (welding position)	Welding positions	ISO6947 corresponding code
of plates	Vu	Vertical upwards welding	PF
	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	H-L045
	6GR	Welding of pipes fixed at 45 ° inclination with restriction ring	-
Fillet welding of plates	FF	Fillet flat welding	PA
	FH	Fillet horizontal 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	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

4.3.8 Tack welding

4.3.8.1 A welder qualified for butt or fillet welding according to the requirements of Section 2 of this Chapter can be engaged in tack welding for the welding process and position corresponding to those permitted in his certificate.

Alternatively, welders engaged in tack welding only can be qualified on the test assemblies shown in Figure 4.2.2.7(a) or Figure 4.2.2.7(b).

Section 4 QUALIFICATION TESTS AND EVALUATION OF UNDERWATER WELDERS

4.4.1 Test requirements

4.4.1.1 The qualification tests of underwater welders is to be in accordance with the provisions of this Section. Welding of test assemblies and testing of test specimens are to be witnessed by the Surveyor, consist of a basic knowledge test and an operational skill test. An applicant is qualified to take the operational skill test only after he has successfully passed the basic knowledge test.

4.4.1.2 The basic knowledge test is in general to include the basic knowledge of normal base metals, welding consumables, welding equipment, welding procedures, common underwater welding defects and underwater inspection technologies, offshore structures as well as safety of underwater welding. The scope of the test is subject to approval by CCS.

4.4.1.3 2 Prior to the operational skill qualification test, the Qualification Test Committee is to submit the intended qualification grades of welders welding positions, material groups, thickness of test assemblies (pipe diameter), joint types and edge preparation dimensions to CCS for

confirmation.

~~4.4.1.4 The applicants are to take the operational skill test as specified in this Section. The test is to be carried out under the supervision of the Surveyor.~~

4.4.1.53 The ~~operational skill~~ qualification test of underwater welders consists of wet welding and local dry welding.

Wet welding means welding directly carried out by underwater welders in water without any drainage of water. Local dry welding means the welding carried out by underwater welders with drainage of water in the local area to be welded by gas-shielded means.

4.4.1.64 Welders who have passed the test of wet welding can only be engaged in wet welding. Welders who have passed the test of local dry welding can only be engaged in local dry welding.

4.4.1.75 Welding consumables for the tests are to be suitable for base metals.

4.4.1.86 The applicant may select a depth of water at his discretion according to the actual working conditions.

4.4.6 Application

4.4.6.4 ~~The range of welding positions are the same as those specified in Table 4.3.7.1a and 4.3.7.1c in this Chapter. The principle for welding positions is that a higher welder grade covers low welder grades. The welding positions for fillet welds in respect to welder qualification grade are shown in Table 4.4.6.4.~~

~~Welding positions for test items of various joint types~~ — ~~Table 4.4.6.4~~

Welder grade	Range of qualification for fillet welding of plates	Range of qualification for pipe-to-plate fillet welding
I	FF, FH	=
II	FF, FH, FVd	=
III	FF, FH, FVd, FO	=
I _p	FF, FH	2FG
II _p	FF, FH, FVd, FO	2FG, 4FG, 5FG
III _p	FF, FH, FVd, FO	2FG, 4FG, 5FG, 6FG

CHAPTER 5 WELDING OF HULL STRUCTURES

Section 2 WELDING OF HULL STRUCTURAL MEMBERS

5.2.5 Welding of shear strakes to strength deck stringers

5.2.5.1 Where strength deck stringers are fillet welded to shear strakes with plate thickness being equal to or greater than 15 mm, at least partial full-penetration welding is to be adopted and the edges of the strength deck plates are to be beveled on one or both sides of the plates, with root face being not greater than t/3 or 10 mm (whichever is less), and a certain root gap is to be left to ensure deep fusion.

Section 3 INSPECTION AND REPAIRING OF WELDS

(6) For welds with large section, especially welds of steel castings and steel forgings as well as welds welded under stress or low temperature, 100% surface crack examination is to be carried out. Other welds with large section beveled on one side or both sides (plate thickness 30 mm or

above) and thick fillet welds, such as welds on stern frames, welded mast and bulkhead stool, 100% surface crack examination is ~~in general~~ to be carried out.

CHAPTER 7 WELDING OF PRESSURE SHELLS

Section 1 GENERAL PROVISIONS

7.1.3 Approval

7.1.3.1 Unless provided otherwise in the Appendix to Chapter 3, PART ONE of CCS Rules for Classification of Sea-going Steel Ships, manufacturers of pressure shells ~~(except for Class III pressure vessels)~~ are to apply to CCS for works approval.

CHAPTER 8 WELDING OF IMPORTANT MACHINERY COMPONENTS

Section 4 NON-DESTRUCTIVE INSPECTION AND WELD REPAIRS OF PROPELLERS

8.4.4 General requirements for repairs

8.4.4.1 The rectification of small defects which do not themselves adversely affect the strength of the casting is generally not required. Where local pores are present in the surface of the end face or bore of a propeller boss, they may be filled with a suitable plastic filler after the appropriate preparation of the defective area.

8.4.4.2 Indications exceeding the acceptance criteria of Table 8.4.3.5 (e.g. cracks, shrinkage cavities, sand, slag and other non-metallic inclusions, blowholes and other defects which may impair the safe service of the propeller) are to be rectified or repaired by welding as necessary. ~~Small surface defects such as scattered circular blowholes having a diameter less than 1 mm may be repaired.~~