



CHINA CLASSIFICATION SOCIETY

CCS Rule Change Notice For:

Rules for Construction of Ocean-going Steel Fishing Vessels

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Steel Fishing Vessels**

PART 7 MATERIALS

CHAPTER 5 STEEL CASTINGS

Section 6 STEEL CASTINGS FOR PROPELLERS

5.6.1 Application

5.6.1.1 The requirements of this Section apply to propellers (including blades and bosses) in carbon, carbon-manganese, low alloy or stainless steel castings. ~~and blades in carbon, carbon-manganese, low alloy or stainless steel castings. If alloy steel is used, its chemical composition, mechanical properties and heat treatment procedures are to be submitted to CCS for approval.~~

5.6.1.2 The steel castings for propellers and their components are to be manufactured in accordance with the relevant requirements in Section 1 of this Chapter.

5.6.2 Chemical composition

5.6.2.1 The chemical composition of ladle samples for castings for carbon and carbon-manganese steel propellers is to comply with the requirements given in Table 5.6.2.1, ~~but the carbon content is not to be higher than 0.25%.~~

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

Table 5.6.2.1

Steel type	Chemical composition (%)								
	C	Si	Mn	P	S	Residual elements ^①			
						Ni	Cr	Mo	Cu
carbon and carbon-manganese steel	≤0.25	≤0.60	0.50~1.60	≤0.04	≤0.04	≤0.40	≤0.30	≤0.15	≤0.30

Note: ① The total content of residual elements is to be not more than 0.80%.

5.6.2.2 The chemical composition of ladle samples for castings for stainless steel propellers is to comply with the requirements given in Table 5.6.2.2.

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

Table 5.6.2.2

Steel type	Type ^①	Chemical composition (%)							
		C	Si	Mn	P	S	Ni	Cr	Mo ^②
1Cr12NiMo	M/F	≤0.15	≤1.5	≤2.0	≤0.035	≤0.030	≤2.0	11.5~17.0	≤0.5
0Cr13Ni4Mo	M/F	≤0.06	≤1.0	≤2.0	≤0.035	≤0.030	3.5~5.0	11.5~17.0	≤1.0
0Cr16Ni5Mo	M/F	≤0.06	≤1.5	≤2.0	≤0.035	≤0.030	3.5~6.0	15.0~17.5	≤1.5
1Cr18Ni12Mo	A	≤0.12	≤1.5	≤1.6	≤0.035	≤0.030	8.0~13.0	16.0~21.0	≤4.0

Note: ① M - Martensitic, F - Ferritic, A - Austenitic.

② Minimam values are to be in accordance with international or national standards.

5.6.3 Heat treatment

5.6.3.1 The castings for carbon and carbon-manganese steel propellers are to be heat treated as follows:

- (1) fully annealed; or
- (2) normalized; or
- (3) normalized and tempered at a temperature of not less than 550°C.

5.6.3.2 The castings for stainless steel propellers are to be heat treated in accordance with their steel type as follows:

- (1) Martensitic castings are to be austenitized and annealed;
- (2) Austenitic castings are to be solution heated.

5.6.4 Mechanical properties

5.6.4.1 At least one test sample is to be taken from material representing each casting. Where a number of propeller castings of the same size, and less than 1 m in diameter are made from one cast and heat treated in the same furnace charge, at least one test sample of suitable dimensions is to be provided for each multiple of five castings in the batch. ~~The test material is to be cast integral with the steel casting body of the propeller hub or blade flange.~~

5.6.4.2 The test material is to be cast integral with the castings. The test material attached on blades is to be located in an area between 0.5 and 0.6 times the radius of the propeller. Separately cast test bars from the same ladle on the castings may be used subject to prior approval of CCS. ~~At least one tensile specimen and one set of 3 Charpy V-notch impact specimens are to be intercepted for each steel casting.~~

5.6.4.3 The test material is to be heat treated together with the castings in the same furnace charge. The test material is not to be removed from the casting until the final heat treatment has been carried out. Removal is to be by machining.

5.6.4.4 At least one tensile test specimen and one set of three Charpy V-notch impact test specimens are to be cut from each test sample, and such specimens are to be tested in accordance with the relevant requirements in Chapter 2 of this PART.

5.6.4.35 The mechanical properties of steel castings for propellers are to comply with the requirements of Table 5.6.4.35.

Mechanical Properties of Steel Castings for Propellers

Table 5.6.4.35

Steel type		Tensile strength R_m min. (N/mm ²)	Yield strength R_{eH} or $R_{p0.2}$ min. (N/mm ²)	Elongation A_5 min. (%)	Reduction of area Z min. (%)	Average energy for Charpy V notch impact test $\odot$ min. (J)
Carbon and carbon-manganese steel		400	200	25	40	20
Low alloy		400	225	19	25	20
Stainless	1Cr12NiMo	590	440	15	30	20
	0Cr13Ni4Mo	750	550	15	35	30
	0Cr16Ni5Mo	760	540	15	35	30
	1Cr18Ni12Mo	440	180 ^①	30	40	-

Note: ① The impact tests are to be made at 0°C on propeller castings for ships without Ice Class Notation or with Ice Class Notation B at -10°C on propeller castings for ships with other Ice Class Notations. The impact tests need not be required for austenitic stainless steel castings.

- ② Where the yield strength of austenitic stainless steel is defined as the 1.0% proof strength, $R_{p1.0}$ is to be not less than 205 N/mm².

5.6.5 Inspections

5.6.5.1 All finished propeller castings are to be 100% visually inspected, the surfaces of the finished castings are to be in accordance with the roughness specified in the approved drawings and free from cracks or other imperfections which will interfere with the use of the castings.

5.6.5.2 All propellers are subject to non-destructive testing. The categorization of important portions of the propellers and the corresponding non-destructive testing are to comply with the provisions given in [in Section 4, Chapter 6 of PART 8](#) of *CCS RULES FOR MATERIALS AND WELDING*.

5.6.5.3 The dimensions of the propellers are to be the responsibility of the manufacturer and the report on the dimensional inspection is to be handed over to the Surveyor for confirmation in his presence.

5.6.5.4 Static balancing is to be carried out on all propellers in accordance with the approved drawing. Dynamic balancing may be required for propellers running above 500 r/min.

5.6.5.5 Defects found in the inspections are to be repaired in accordance with [in Section 4, Chapter 6 of PART 8](#) of *CCS RULES FOR MATERIALS AND WELDING*. The Surveyor may require areas to be etched for the purpose of investigating weld repairs.

5.6.6 Identification and certification

5.6.5.1 Each casting is to be suitably identified by the manufacturer with the following:

- a) heat number or other marking which will enable the full history of the casting to be traced;
- b) CCS certificate number;
- c) ice class symbol, where applicable;
- d) skew angle for high skew propellers;
- e) date of final inspection;
- f) CCS stamp is to be put on when the casting has been accepted.

5.6.5.2 The manufacturer is to provide the Surveyor with a marine product certificate or equivalent document giving the following particulars for each casting which has been accepted:

- a) purchaser's name and order number;
- b) vessel identification, where known;
- c) description of the casting with drawing number;
- d) diameter, number of blades, pitch, direction of turning;
- e) skew angle for high skew propellers;
- f) final mass;
- g) alloy type, heat number and chemical composition;
- h) casting identification number;
- i) details of time and temperature of heat treatment;
- j) results of the mechanical tests and non-destructive testing.

CHAPTER 9 OTHER NON-FERROUS METALS

Section 1 COPPER CASTINGS FOR PROPELLERS

9.1.1 Application

9.1.1.1 The requirements of this Section apply to cast copper alloy ~~castings for manufacturing~~ propellers (including ~~hubs and~~ blades and bosses).

9.1.1.2 ~~The castings are to be manufactured and inspected~~ Cast copper alloy propellers and their components are to be manufactured and tested in accordance with the requirements of given in this Section and Chapters 1 and 2 of this PART.

9.1.2 Manufacture

9.1.2.1 Manufacturers (including foundries and machining works) are to apply for works approval in accordance with the relevant requirements of CCS.

9.1.2.2 The approved works are to be subject to periodical verification by CCS, covering the quality assurance system and the technical conditions and accuracy of production, testing and inspection facilities. The manufacturers not frequently engaged in producing such castings are to be checked in accordance with the details of the approval test, in addition to the fore-mentioned requirements.

~~9.1.3 Quality~~

~~9.1.3.1 There should be no cracks, blow holes, shrinkage holes, cold insulation, scars, large non-metallic inclusions and other defects that affect the use on the castings.~~

9.1.3.4 Chemical composition

9.1.3.4.1 The chemical composition of copper alloy propellers and their components is ~~ladle samples of the castings is~~ generally to be as given in Table 9.1.3.4.1. For chemical composition of alloys other than those given in Table 9.1.3.4.1, the related information (including chemical composition, heat treatment procedure, mechanical properties and seawater corrosion resistance) is to be submitted, which may be accepted in accordance with relevant recognized standards subject to agreement of CCS.

Typical Chemical Composition of Copper Alloy Propellers **Table 9.1.3.4.1**

Copper alloy Type	Chemical composition (%)							
	Cu	Al	Mn	Zn	Fe	Ni	Sn	Pb
Grade 1 manganese bronze (Cu1)	52~62	0.5~3.0	0.5~4.0	35~40	0.5~2.5	≤1.0	≤1.5	≤0.5
Grade 2 Ni-manganese bronze (Cu2)	50~57	0.5~2.0	1.0~4.0	33~38	0.5~2.5	2.5~8.0	≤1.5	≤0.5
Grade 3 Ni-aluminum bronze (Cu3)	77~82	7.0~11.0	0.5~4.0	≤1.0	2.0~6.0	3.0~6.0	≤0.1	≤0.03
Grade 4 Mn-aluminum bronze (Cu4)	70~80	6.5~9.0	8.0~20.0	≤6.0	2.0~5.0	1.5~3.0	≤1.0	≤0.05

9.1.3.2 For alloys Grades Cu1 and Cu2, the proportions of α and β phases are to be

determined by the manufacturer. The proportion of α phase is to be not less than 25% and that of β phase is to be kept low so as to ensure adequate cold ductility and corrosion fatigue resistance.

9.1.34.32 In order to ensure the proportions of α phase in microstructure of Cu1 and Cu2, zinc equivalent of copper alloy is not to exceed 45%. Zinc equivalent is to be defined by the following formula: The zinc equivalent of Cu1 and Cu2 copper alloys are to be determined as per the following formula, and is not to exceed 45%.

$$\text{Zinc equivalent (\%)} = 100 - \frac{100 \times \text{Cu\%}}{100 + A}$$

Where: $A = 1 \times \text{Sn\%} + 5 \times \text{Al\%} - 0.5 \times \text{Mn\%} - 0.1 \times \text{Fe\%} - 2.3 \times \text{Ni\%}$;

Where the proportion of α phase is or above 25%, the zinc equivalent may not be required.

~~A is algebraic sum of the following items: $1 \times \text{Sn\%}$;~~

~~$5 \times \text{Al\%}$;~~

~~$-0.5 \times \text{Mn\%}$;~~

~~$-0.1 \times \text{Fe\%}$;~~

~~$-2.3 \times \text{Ni\%}$.~~

~~9.1.4.3 If the castings are cast with the same copper alloy ingots that have been molten, the chemical composition report provided by the ingot manufacturer may be used.~~

9.1.45 **Manufacture and heat treatment**

9.1.45.1 The pouring is to be carried out into dried moulds using degassed liquid metal. The pouring is to be controlled to avoid turbulent flow. Special devices are to be used to prevent slag flowing into the mould.

9.1.4.2 Casting defects which may impair the serviceability of the castings, e.g. major non-metallic inclusions, shrinkage cavities, blow holes and cracks are not permitted.

9.1.4.3 Where specimens are taken from separately cast sample pieces, the samples are to be cast in moulds made of the same material as the mould for the propeller and they are to be cooled down under the same conditions as the propeller.

9.1.4.4 For castings of propellers or their components, subsequent stress relieving heat treatment may be performed to reduce the residual stresses. A specification containing the details of the heat treatment is to be submitted to CCS for examination. For stress relieving temperatures and soaking time, see Table 9.1.4.4.

Soaking Time for Stress Relief Heat Treatment of Copper Alloy Propellers Table 9.1.4.4

Alloy grade Soaking time Stress relief temperature(°C)	Cu1 and Cu2		Cu3 and Cu4	
	Hours per 25 mm thickness (h)	Max recommended total time hours (h)	Hours per 25 mm thickness (h)	Max recommended total time hours (h)
350	5	15	-	-
400	1	5	-	-
450	1/2	2	5	15
500	1/4	1	1	5

Alloy grade Soaking time Stress relief temperature(°C)	Cu1 and Cu2		Cu3 and Cu4	
	Hours per 25 mm thickness (h)	Max recommended total time hours (h)	Hours per 25 mm thickness (h)	Max recommended total time hours (h)
550	1/4 ^①	1/2 ^①	1/2 ^②	2 ^②
600	-	-	1/4 ^②	1 ^②

Notes: ① Applicable to Cu2 alloys.

② Applicable to Cu4 alloys only.

9.1.4.5.4 Castings may be supplied in either the as-cast or properly heat treated condition.

9.1.5 Test samples

9.1.5.1 For cast copper alloy propellers, separately cast keel block type test samples as given in Figure 9.1.5.1 are generally used. Where possible, test bars attached on blades are to be located in an area between 0.5 R and 0.6 R (R being the radius of the propeller). Separately cast test samples in accordance with other recognized standards may be used.

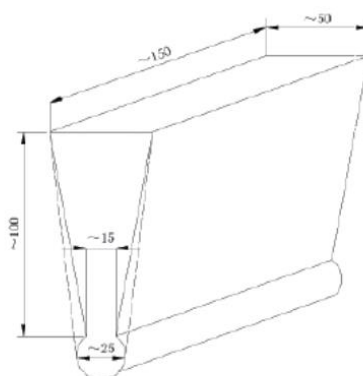


Figure 9.1.5.1 Keel Type Test Sample

9.1.5.2 Usually at least 1 mechanical test sample is to be taken from each ladle of liquid metal and the sample is usually to be cast towards the end of pouring process.

9.1.5.3 Where a batch of propellers made and heat treated from one cast with same shape and dimensions, at least one sample is to be provided for each multiple of five casings in the batch provided that the following conditions are met:

(1) integrally cast propeller with a diameter not greater than 1 m;

(2) for controllable pitch propeller, the weight of each blade or propeller hub not more than 200 kg.

9.1.5.4 Where propellers are subjected to a heat treatment, the test samples are to be heat treated together with them. The test sample material is to be removed from the casting by non-thermal procedures.

9.1.5.5 Round proportional tensile test specimens are to be cut from each test sample in accordance with the requirements given in Item 2 of Table 2.2.2.1 of PART 1 of CCS RULES FOR MATERIALS AND WELDING.

9.1.6 Testing and inspections **Mechanical properties**

9.1.6.1 Analysis of the chemical composition is required on each cast of copper alloy propellers and their components, and the results of the analysis are to comply with the relevant requirements of 9.1.3 of this Section. ~~Specimens are to be prepared for the castings in accordance with the following requirements:~~

- ~~.1 Specimens are to be made of the same casting material as the casting molds of the propeller castings, and are to be cast separately under the same cooling conditions, as shown in Figure 9.1.6.1.1. If a casting is made by pouring several furnaces of copper water, each furnace or lad of copper water is to be sampled.~~
- ~~.2 If only one specimen is needed, the specimen is to be cast at the end of the casting process. If several specimens are needed, they are to be cast respectively at the beginning and end of the casting process.~~
- ~~.3 The dimensions of tensile specimens are to comply with the provisions of serial number 1 in Table 2.2.2.1.~~

9.1.6.2 Samples for metallographic examination are to be prepared from every melt of Grades Cu1 and Cu2 alloys. The proportion of α phase determined from the average of 5 counts is to comply with the requirements of 9.1.3.2.

9.1.6.23 The tensile strength, 0.2% proof strength and elongation are to be determined by mechanical tests. Test results of test specimens taken from separately cast samples are to comply with the values given in Table 9.1.6.3. For integrally cast test specimens the mechanical characteristics are to be specially agreed with CCS. ~~The tensile test results are to comply with the provisions of Table 9.1.6.2.~~

Mechanical Properties of Copper Propeller Castings

Table 9.1.6.23

Type of copper alloy	Proof strength $R_{p0.2}$ (N/mm ²)	Tensile strength R_m (N/mm ²)	Elongation A_5 (%)
Grade 1 manganese bronze(Cu1)	≥175	≥440	≥20
Grade 2 Ni-manganese bronze(Cu2)	≥175	≥440	≥20
Grade 3 Ni-manganese bronze(Cu3)	≥245	≥590	≥16
Grade 4 Mn-aluminum bronze(Cu4)	≥275	≥630	≥18

~~Note: Unless otherwise specified, the specified non-proportional extension strength in the table $R_{p0.2}$ is only for reference.~~

9.1.6.4 Propeller castings are to be visually examined at all stages of manufacture and the whole surface is to be subjected to a comprehensive visual examination in the finished condition by the Surveyor. This examination is also to include the bore.

9.1.6.5 The dimensions, geometrical tolerances and surface roughness are to be checked by the manufacturer and the report on the dimensional inspection is to be handed over to the Surveyor, who may require checks to be made in his presence. The inspection results are to be in accordance with the approved drawings.

9.1.6.6 Minor casting defects such as small sand and slag inclusions, small cold shuts and scabs are to be trimmed. Casting defects which may impair the serviceability of the castings, e.g.

major non-metallic inclusions, shrinkage cavities, blow holes and cracks are to be removed by a proper method and repaired in accordance with the relevant requirements in Section 4, Chapter 6 of PART 8 of CCS RULES FOR MATERIALS AND WELDING.

9.1.6.7 Each propeller and its components are to be subject to a non-destructive examination in accordance with the relevant requirements in Section 4, Chapter 6 of PART 8 of CCS RULES FOR MATERIALS AND WELDING and a report of the non-destructive examination is to be provided.

9.1.6.8 Where any defect to be repaired are found, the repair is to be carried out in accordance with the relevant requirements in Section 4, Chapter 6 of PART 8 of CCS RULES FOR MATERIALS AND WELDING..And the repaired portion is to be subject to NDT for certifying that the product is as required.

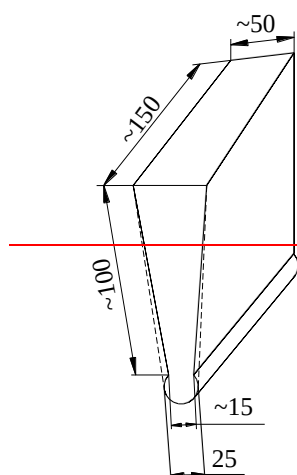
9.1.6.9 The Surveyor may require areas to be etched (e.g. by iron chloride) for the purpose of investigating weld repairs.

9.1.6.10 Static balancing is to be carried out on all propellers in accordance with the approved drawing. Dynamic balancing is to be carried out for propellers running above 500 r/min.

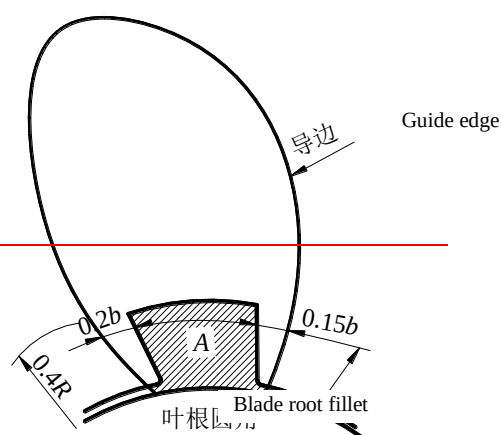
9.1.7 Visual and non-destructive testing

~~9.1.7.1 All finished castings are to be submitted to the Surveyor from CCS for inspection of internal and external surfaces.~~

~~9.1.7.2 For single cast blades with a finished mass of more than 3t, a surface is to be polished on the pressure surface of each blade for visual inspection and dye penetrant testing. The polished surface area is to include Area A and root rounded corner areas as shown in Figure 9.1.7.2.~~



~~Figure 9.1.6.1.1 Keel Type Test Piece~~



~~Figure 9.1.7.2 Schematic Diagram of Area A and Blade Root Fillet~~

~~9.1.7.3 The results of dye penetrant testing are to comply with other accepted standards.~~

9.1.8 Macrostructure examination

~~9.1.8.1 Macrostructure examination is to be conducted on Grade 1 manganese bronze and Grade 2 Ni-manganese bronze on a furnace by furnace basis. To ensure sufficient toughness, the average calculated from the five readings is to contain at least 25% of α metallographic structure.~~

9.1.9 Rectification of defects

~~9.1.9.1 Generally, minor defects that do not affect the strength may not be repaired. After proper treatment, suitable plastic fillers can be used to fill the local pores on the end face of the hub or the surface of the inner hole.~~

~~9.1.9.2 When excess defect is found in the castings, they can be removed mechanically and the pits generated hereby are to be polished smooth. After the removal of the defect, dye penetrant testing is to be conducted to prove that the defect has been eliminated.~~

~~9.1.9.3 Generally, welding repair is not to be conducted on propellers. If necessary, they are to be repaired in accordance with the relevant provisions of Section 4, Chapter 6, PART 8 herein, and non-destructive testing is to be conducted to verify that the products meet the requirements.~~

9.1.710 Marking and certification

9.1.710.1 Each propeller casting is to be marked by the manufacturer at least with the following:

- a) grade of cast material or corresponding abbreviated designation;
- b) manufacturer's mark;
- c) heat number or other marking which will enable the full history of the casting to be traced;
- d) specimen number;
- e) number of CCS certificate;
- f) ice class notation, where applicable;
- g) skew angle for high skew propellers;
- h) date of final inspection;
- i) CCS stamp, where the casting is found satisfactory.

9.1.710.2 Each satisfactorily inspected propeller casting is to be provided with a marine product certificate or equivalent document containing the following details:

- a) purchaser's name and order number;
- b) ship's name, if known;
- c) description of the casting with drawing number;
- d) diameter, number of blades, pitch, direction of turning;
- e) skew angle for high skew propellers;
- f) final weight;
- g) alloy type, heat number and chemical composition;
- h) heat or casting number;
- i) casting identification number;
- j) method and results of non-destructive testing;
- k) results of mechanical tests;
- l) proportion of α phase in metallographic examination (for Cu1 and Cu2 alloys only).



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Steel Fishing Vessels**

PART 8 WELDING

Appendix 1 is added as follows:

APPENDIX 1 NON-DESTRUCTIVE TESTING OF SHIP HULL STEEL WELDS

1 General

1.1 This document gives minimum requirements on the methods and quality levels that are to be adopted for the non-destructive testing (NDT) of ship hull structure steel welds during new building (“hull structure” as defined in Appendix1,Chapter 4, PART 1 of CCS RULES FOR *CLASSIFICATION OF SEA-GOING STEEL SHIPS*).

1.2 The quality levels given in this Appendix refer to production quality and not to fitness-for-purpose of the welds examined.

1.3 The NDT is normally to be performed by the Shipbuilder or its subcontractors in accordance with these requirements. The CCS Surveyor may require witnessing of the testing.

1.4 It is the Shipbuilder’s responsibility to assure that testing specifications and procedures are adhered to during the construction and the reports are made available to CCS on the findings made by the NDT.

1.5 The extent of testing and the number of checkpoints are to be agreed between the Shipbuilder and CCS.

1.6 This Appendix covers conventional NDT methods. Advanced non-destructive testing (ANDT) methods such as phased array ultrasonic testing (PAUT), time of flight diffraction (TOFD), digital radiography (RT-D), radiosopic testing (RT-S), and computed radiography (RT-CR) are separately prescribed .

1.7 The following terms and definitions apply for this Appendix.

NDT Non-Destructive Testing - the development and application of technical methods to examine materials or components in ways that do not impair their future usefulness and serviceability, in order to measure geometrical characteristics and to detect, locate, measure and evaluate flaws. NDT is also known as non-destructive examination (NDE), non-destructive inspection (NDI) and non-destructive evaluation (NDE).

RT Radiographic Testing

UT Ultrasonic Testing

MT Magnetic Particle Testing

PT Dye or Liquid Penetrant Testing

PWHT Post Weld Heat Treatment

VT Visual Testing

2 Application

2.1 Base Metals

2.1.1 This Appendix applies to fusion welds made in normal and higher strength hull structural steels, high strength steels for welded structures and connections welds with hull steel forgings and hull steel castings . Base metal other than the above may be applied by CCS.

2.2 Welding processes

2.2.1 This Appendix applies to fusion welds made using manual metal arc welding (shielded metal arc welding, 111), gas-shielded metal arc welding (gas metal arc welding, including flux cored arc welding, 13x), gas-shielded arc welding with non-consumable tungsten electrode (gas tungsten arc welding, 14x), submerged arc welding (12x), electro-slag welding (72x) and electro-gas welding processes (73). Terms and numbers according to ISO 4063:2009 ("x" indicates that relevant subgroups are included). This Appendix may also be applied to welding processes other than the above at the discretion of CCS.

2.3 Weld joints

2.3.1 This Appendix applies to butt welds with full penetration, tee, corner and cruciform joints with or without full penetration, and fillet welds.

2.4 Timing of NDT

2.4.1 NDT shall be conducted after welds have cooled to ambient temperature and after post weld heat treatment where applicable.

2.4.2 For high strength steels for welded structure with specified minimum yield stress in the range of 420 N/mm² to 690 N/mm², NDT shall not be carried out before 48 hours after completion of welding. For steel with specified minimum yield greater than 690 N/mm² NDT shall not be carried out before 72 hours after completion of welding. Regardless of yield strength consideration is to be given to requiring a delayed inspection where evidence of delayed cracking has been observed in production welds.

2.4.3 At the discretion of the surveyor, a longer interval and/or additional random

inspection at a later period may be required, (for example in case of high thickness welds).

2.4.4 At the discretion of the surveyor, the 72 hour interval may be reduced to 48 hours for RT or UT inspection, provided there is no indication of delayed cracking, and a complete visual and random MT or PT inspection to the satisfaction of the surveyor is conducted 72 hours after welds have been completed and cooled to ambient temperature.

2.4.5 Where PWHT is carried out the requirement for testing after a delay period may be relaxed, at the discretion of the surveyor.

2.5 Applicable methods for testing of weld joints

2.5.1 The methods mentioned in this Appendix for detection of surface imperfections are VT, PT and MT. The methods mentioned for detection of internal imperfections are UT and RT.

2.5.2 Applicable methods for testing of the different types of weld joints are given in Table 2.5.2.

Applicable methods for testing of weld joints

Table 2.5.2

WELD JOINT	PARENT MATERIAL THICKNESS	APPLICABLE TEST METHODS
Butt welds with full penetration	thickness < 8mm ¹	VT, PT, MT, RT
	thickness ≥ 8mm	VT, PT, MT, UT, RT
Tee joints, corner joints and cruciform joints with full penetration	thickness < 8mm ¹	VT, PT, MT, RT ³
	thickness ≥ 8mm	VT, PT, MT, UT, RT ³
Tee joints, corner joints and cruciform joints without full penetration and fillet welds	All	VT, PT, MT, UT ² , RT ³

Notes:

¹ In cases of thickness below 8mm CCS may consider application of an appropriate advanced UT method.

² UT may be used to check the extent of penetration in tee, corner and cruciform joints. This requirement is to be agreed with CCS.

³ RT may be applied however there will be limitations

3 Qualification of personnel involved in NDT

3.1 The Shipbuilder or its subcontractors is responsible for the qualification and preferably 3rd party certification of its supervisors and operators to a recognised certification scheme based on ISO 9712:2012.

Personnel qualification to an employer based qualification scheme as e.g. SNT-TC-1A, 2016 or ANSI/ASNT CP-189, 2016 may be accepted if the Shipbuilder or its subcontractors written practice is reviewed and found acceptable by the Society. The Shipbuilder or its subcontractors written practice shall as a minimum, except for the impartiality requirements of a certification body and/or authorised body, comply with ISO 9712:2012.

The supervisors' and operators' certificates and competence shall comprise all industrial

sectors and techniques being applied by the Shipbuilder or its subcontractors.

Level 3 personnel shall be certified by an accredited certification body.

3.2 The Shipbuilder or its subcontractors shall have a supervisor or supervisors, responsible for the appropriate execution of NDT operations and for the professional standard of the operators and their equipment, including the professional administration of the working procedures. The Shipbuilder or its subcontractors shall employ, on a full-time basis, at least one supervisor independently certified to Level 3 in the method(s) concerned as per the requirements of item 3.1. It is not permissible to appoint Level 3 personnel; they must be certified by an accredited certification body. It is recognised that a Shipbuilder or its subcontractors may not directly employ a Level 3 in all the stated methods practiced. In such cases, it is permissible to employ an external, independently certified, Level 3 in those methods not held by the full-time Level 3(s) of the Shipbuilder or its subcontractors.

The supervisor shall be directly involved in review and acceptance of NDT Procedures, NDT reports, calibration of NDT equipment and tools. The supervisor shall on behalf of the Shipbuilder or its subcontractors re-evaluate the qualification of the operators annually.

3.3 The operator carrying out the NDT and interpreting indications, shall as a minimum, be qualified and certified to Level 2 in the NDT method(s) concerned and as described in item 3.1.

However, operators only undertaking the gathering of data using any NDT method and not performing data interpretation or data analysis may be qualified and certified as appropriate, at level 1.

The operator shall have adequate knowledge of materials, welding, structures or components, NDT equipment and limitations that are sufficient to apply the relevant NDT method for each application appropriately.

4 Surface condition

4.1 Areas to be examined shall be free from scale, slag, loose rust, weld spatter, oil, grease, dirt or paint that might affect the sensitivity of the testing method.

4.2 Preparation and cleaning of welds for subsequent NDT are to be in accordance with the accepted NDT procedures, and are to be to the satisfaction of the surveyor. Surface conditions that prevent proper interpretation may be cause for rejection of the weld area of interest.

5 General plan of testing: NDT method selection

5.1 The extent of testing and the associated quality levels are to be planned by the Shipbuilder according to the ship design, ship type and welding processes used. For new construction survey reference is to be made to the NDT requirements of Appendix 1, Chapter 4, PART 1 of *CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS*.

5.2 For each construction, the Shipbuilder shall submit a plan for approval by CCS, specifying the areas to be examined and the extent of testing and the quality levels, with reference to the NDT procedures to be used. Particular attention is to be paid to inspecting welds in highly stressed areas and welds in primary and special structure indicated in Part 2 of this Rule. The NDT procedure(s) shall meet the requirement stated in section 6 of this Appendix and the specific requirements of CCS. The plan shall only be released to the personnel in charge of the NDT and its supervision.

5.2.1 In selecting checkpoints, emphasis shall be given to the following inspection locations:

- (1) Welds in high stressed areas
- (2) Fatigue sensitive areas
- (3) Other important structural elements
- (4) Welds which are inaccessible or very difficult to inspect in service
- (5) Field erected welds
- (6) Suspected problem areas

5.2.2 Block construction welds performed in the yards, or at subcontracted yards/facilities, are to be considered in selecting checkpoints.

5.2.3 If an unacceptable level of indications are found the NDT extent is to be increased.

5.3 The identification system shall identify the exact locations of the lengths of weld examined.

5.4 All welds over their full length are to be subject to VT by personnel designated by the Shipbuilder, who may be exempted from the qualification requirements defined in section 3 of the UR.

5.5 As far as practicable, PT or MT shall be used when investigating the outer surface of welds, checking the intermediate weld passes and back-gouged joints prior to subsequent passes deposition. MT shall be performed in ferromagnetic materials welds unless otherwise agreed with CCS. Surface inspection of important tee or corner joints, using an approved MT or PT method,

shall be conducted to the satisfaction of the surveyor.

5.6 Welded connections of large cast or forged components (e.g. stern frame, stern boss, rudder parts, shaft brackets...) are to be tested over their full length using MT (MT is the preferred method) or PT, (PT is to be applied for non-ferrous metals) and at agreed locations using RT or UT.

5.7 As given in Table 2.5.2, UT or RT or a combination of UT and RT may be used for testing of butt welds with full penetration of 8mm or greater. Methods to be used shall be agreed with CCS. The method used shall be suited for the detection of particular types and orientations of discontinuities. RT and UT are used for detection of internal discontinuities, and in essence they supplement and complement each other. RT is generally most effective in detecting volumetric discontinuities (e.g. porosity and slag) whilst UT is more effective for detecting planar discontinuities (e.g. laminations, lack of fusion and cracks). Although one method may not be directly relatable to the other, either one would indicate conditions of inadequate control of the welding process.

5.8 In general start/stop points in welds made using automatic (mechanized) welding processes are to be examined using RT or UT, except for internal members where the extent of testing is to be agreed with the attending surveyor.

5.9 Where the surveyor becomes aware that an NDT location has been repaired without a record of the original defect, the shipyard is to carry out additional examinations on adjacent areas to the repaired area to the satisfaction of the attending surveyor. Reference is to be made to Appendix1, Chapter 4, PART 1 of *CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS*.

6 Testing

6.1 General

6.1.1 The testing method, equipment and conditions shall comply with recognized National or International standards, or other documents to the satisfaction of CCS.

6.1.2 Sufficient details shall be given in a written procedure for each NDT technique submitted to CCS for acceptance.

6.1.3 The testing volume shall be the zone which include the weld and parent material for at least 10mm each side of the weld, or the width of the heat affected zone (HAZ), whichever is

greater. In all cases inspection shall cover the whole testing volume.

6.1.4 Provision is to be made for the surveyor to verify the inspection, reports and records (e.g. radiographs) on request.

6.2 Visual testing (VT)

6.2.1 The personnel in charge of VT is to confirm that the surface condition is acceptable prior to carrying out the inspection. VT shall be carried out in accordance with standards agreed between the Shipbuilder and CCS.

6.3 Liquid penetrant testing (PT)

6.3.1 PT shall be carried out in accordance to ISO 3452-1:2013 or a recognized accepted standard and the specific requirement of CCS.

6.3.2 The extent of PT shall be in accordance to the plans agreed with the attending surveyor and to the satisfaction of the surveyor.

6.3.3 The surface to be examined shall be clean and free from scale, oil, grease, dirt or paint so there are not contaminants and entrapped material that may impede penetration of the inspection media.

6.3.4 The temperature of parts examined shall be typically between 5 °C and 50 °C, outside this temperature range special low/high temperature penetrant and reference comparator blocks shall be used.

6.4 Magnetic particle testing (MT)

6.4.1 MT shall be carried out in accordance to ISO 17638:2016 or a recognized accepted standard and the specific requirement of CCS.

6.4.2 The extent of MT shall be in accordance to the plans agreed with the attending surveyor and to the satisfaction of the surveyor.

6.4.3 The surface to be examined shall be free from scale, weld spatter, oil, grease, dirt or paint and shall be clean and dry. In general, the inside and outside of the welds to be inspected need to be sufficiently free from irregularities that may mask or interfere with interpretation.

6.5 Radiographic testing (RT)

6.5.1 RT shall be carried out in accordance to ISO 17636-1:2013 or an accepted recognized standard and any specific requirement of CCS

6.5.2 The minimum inspected weld length for each checkpoint is to be specified in the approved NDT plan (see 5.2) and shall follow the requirements of CCS. For hull welds the

minimum length inspected by RT is typically 300mm.

6.5.2.1 The extent of RT shall be in accordance to the approved plans and to the satisfaction of the surveyor.

6.5.2.2 Consideration may be given for reduction of inspection frequency for automated welds where quality assurance techniques indicate consistent satisfactory quality.

The number of checkpoints is to be increased if the proportion of non-conforming indications is abnormally high.

6.5.3 The inside and outside surfaces of the welds to be radiographed are to be sufficiently free from irregularities that may mask or interfere with interpretation. Surface conditions that prevent proper interpretation of radiographs may be cause for rejection of the weld area of interest.

6.6 Ultrasonic testing (UT)

6.6.1 UT shall be carried out according to procedure based on ISO 17640:2018 (testing procedure), ISO 23279:2017 (characterization) and ISO 11666:2018 (acceptance levels) or accepted standards and the specific requirements of CCS.

6.6.2 The minimum inspected weld length for each checkpoint is to be specified in the approved NDT plan (see 5.2) and shall follow the requirements of CCS.

6.6.2.1 The extent of UT shall be in accordance to the approved plans and to the satisfaction of the surveyor.

6.6.2.2 A checkpoint shall consist of the entire weld length or a length agreed with CCS.

7 Acceptance Levels (criteria)

7.1 General

7.1.1 This section details the acceptance levels (criteria) followed for the assessment of the NDT results. Techniques include but are not limited to: VT, MT, PT, RT and UT.

7.1.2 As far as necessary, testing techniques shall be combined to facilitate the assessment of indications against the acceptance criteria.

7.1.3 The assessment of indications not covered by this Appendix shall be made in accordance with a standard agreed with CCS. Alternative acceptance criteria can be agreed with CCS, provided equivalency is established.

The general accepted methods for testing of welds are provided in Table 7.1.3 (1) and Table 7.1.3 (2) for surface and embedded discontinuities respectively. Refer to ISO 17635:2016.

Method for detection of surface discontinuities (All type of welds including fillet welds)

Table 7.1.3 (1)

Materials	Testing Methods
Ferritic Steel	VT
	VT, MT
	VT, PT

NDT for detection of embedded discontinuities (for butt and T joints with full penetration)

Table 7.1.3 (2)

Materials and type of joint	Nominal thickness (t) of the parent material to be welded (mm)		
	t < 8	8 ≤ t ≤ 40	t > 40
Ferritic butt-joints	RT or UT ¹	RT or UT	UT or RT ²
Ferritic T-joints	UT ¹ or RT ²	UT or RT ²	UT or RT ²

Notes:

¹Below 8mm CCS may consider application of an appropriate advanced UT method.

²RT may be applied however there will be limitations.

7.2 Quality Levels.

Testing requirements follows the designation of a particular quality level of imperfections in fusion-welded joints in accordance with ISO 5817:2014. Three quality levels (B, C and D) are specified.

7.2.1 In general Quality level C is to be applied for hull structure.

7.2.2 Quality level B corresponds to the highest requirement on the finished weld, and may be applied on critical welds.

7.2.3 This standard applies to steel materials with thickness above 0.5 mm. ISO 5817:2014 Table 1 provides the requirements on the limits of imperfections for each quality level. ISO 5817:2014 Annex A also provides examples for the determination of percentage of imperfections (number of pores in surface percent).

7.2.4 All levels (B,C and D) refer to production quality and not to the fitness for purpose (ability of product, process or service to serve a defined purpose under specific conditions). The correlation between the quality levels defined in ISO 5817:2014, testing levels/ techniques and acceptance levels (for each NDT technique) will serve to define the purpose under specific conditions. The acceptance level required for examination shall be agreed with CCS. This will determine the quality level required in accordance with the non-destructive technique selected. Refer to tables 7.5.1 to 7.9.1 (2) .

7.3 Testing Levels.

7.3.1 The testing coverage and thus the probability of detection increases from testing level A to testing level C. The testing level shall be agreed with CCS. Testing level D is intended for special applications, this can only be used when defined by specification. ISO 17640:2018 Annex

A tables A.1 to A.7 provide guidance on the selection of testing levels for all type of joints in relation to the thickness of parent material and inspection requirements.

7.3.2 The testing technique used for the assessment of indications shall also be specified.

7.4 Acceptance Levels.

7.4.1 The acceptance levels are specified for each testing technique used for performing the inspection. The criteria applied is to comply with each standard identified in tables 7.5.1 to 7.9.1 (2) (or any recognized acceptable standard agreed with CCS).

7.4.2 Probability of detection (POD) indicates the probability that a testing technique will detect a given flaw.

7.5 Visual testing (VT)

7.5.1 The acceptance levels and required quality levels for VT are provided in the requirements of Appendix2,Chapter 4, PART 1 of CCS 《RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS》 and Table 7.5.1 below.

Visual testing		Table 7.5.1.
Quality Levels (ISO 5817:2014 applies) ^a	Testing Techniques/ levels (ISO 17637:2016 applies) ^a	Acceptance levels ^b
B	Level not specified	B
C		C
D		D
^a Or any recognized standard agreed with CCS and demonstrated to be acceptable		
^b The acceptance levels for VT are the same to the quality levels requirements of ISO 5817:2014		

7.6 Penetrant testing (PT)

7.6.1 The acceptance levels and required quality levels for PT are provided in Table 7.6.1 below:

Penetrant Testing		Table 7.6.1
Quality Levels (ISO 5817:2014 applies) ^a	Testing Techniques/ levels (ISO 3452-1:2013 applies) ^a	Acceptance levels (ISO 23277:2015 applies) ^a
B	Level not specified	2X
C		2X
D		3X
^a Or any recognized standard agreed with CCS and demonstrated to be acceptable		

7.7 Magnetic Particle testing (MT)

7.7.1 The acceptance levels and required quality levels for MT is provided in Table 7.7.1 below:

Magnetic Particle Testing		Table 7.7.1.
Quality Levels (ISO 5817:2014 applies) ^a	Testing Techniques/ levels (ISO 17638:2016 applies) ^a	Acceptance levels (ISO 23278:2015 applies) ^a
B	Level not specified	2X
C		2X

D		3X
^a Or any recognized standard agreed with CCS and demonstrated to be acceptable		

7.8 Radiographic testing (RT)

7.8.1 The acceptance levels and required quality levels for RT are provided in Table 7.8.1 below. Reference radiographs for the assessment of weld imperfections shall be provided in accordance to ISO 5817:2014 or acceptable recognized standard agreed with CCS.

Radiographic Testing		Table 7.8.1
Quality Levels (ISO 5817:2014 applies) ^a	Testing Techniques/ levels (ISO 17636-1:2013 applies) ^a	Acceptance levels (ISO 10675-1:2016 applies) ^a
B	B (class)	1
C	B ^b (class)	2
D	At least A (class)	3
^a Or any recognized standard agreed with CCS and demonstrated to be acceptable ^b For circumferential weld testing, the minimum number of exposures may correspond to the requirements of ISO 17636-1:2013, class A		

7.9 Ultrasonic testing (UT)

7.9.1 The acceptance levels and required quality levels for UT are provided in Tables 7.9.1 (1) and 7.9.1 (2) below:

Ultrasonic Testing		Table 7.9.1 (1) .
Quality Levels (ISO 5817:2014 applies) ^{a, b}	Testing Techniques/Levels (ISO 17640:2018 applies) ^{a, b}	Acceptance Levels (ISO 11666:2018 applies) ^{a, b}
B	at least B	2
C	at least A	3
D	at least A	3 ^c
^a Or any recognized standard agreed with CCS and demonstrated to be acceptable ^b When characterization of indications is required, ISO 23279:2017 is to be applied ^c UT is not recommended but can be defined in a specification with same requirement as Quality Level C		

Recommended Testing and Quality Levels (ISO 17640)		Table 7.9.1 (2)
Testing Level ^{a,b,c} (ISO 17640:2018 applies)	Quality Level (ISO 5817:2014 applies)	
A	C, D	
B	B	
C	By agreement	
D	Special application	
^a POD increases from testing level A to C as testing coverage increases		
^b Testing Level D for special application shall be agreed with CCS		
^c Specific requirements for testing levels A to C, are provided for various types of joints in ISO 17460:2018 Annex A		

7.9.2 UT Acceptance Levels apply to the examination of full penetration ferritic steel welds, with thickness from 8 mm to 100mm. The nominal frequency of probes used shall be between 2MHz and 5MHz. Examination procedures for other type of welds, material, thicknesses above 100 mm and examination conditions shall be submitted to the consideration of CCS.

7.9.3 The acceptance levels for UT of welds are to be defined in accordance to ISO 11666:2018 requirements or any recognized acceptable standard agreed with CCS. The standard specifies acceptance level 2 and 3 for full penetration welded joints in ferritic steels,

corresponding to quality levels B and C (Refer to table 7.9.1 (1)).

7.9.4 Sensitivity settings and levels. The sensitivity levels are set by the following techniques:

- (1) based on 3mm diameter side- drilled holes
- (2) based on distance gain size (DGS) curves for flat bottom holes (disk-shaped reflectors)
- (3) using a distance-amplitude-corrected (DAC) curve of a rectangular notch of 1mm depth and 1mm width
- (4) using the tandem technique with reference to a 6mm diameter flat-bottom hole (disk shaped reflector)

7.9.5 The evaluation levels (reference, evaluative, recording and acceptance) are specified in ISO 11666:2018 Annex A.

8 Reporting

8.1 Reports of NDT required shall be prepared by the Shipbuilder and shall be made available to CCS.

8.2 Reports of NDT shall include the following generic items:

- (1) Date of testing
- (2) Hull number, location and length of weld inspected
- (3) Names, qualification level and signature of personnel that have performed the testing
- (4) Identification of the component examined
- (5) Identification of the welds examined
- (6) Steel grade, type of joint, thickness of parent material, welding process
- (7) Acceptance criteria
- (8) Testing standards used
- (9) Testing equipment and arrangement used
- (10) Any test limitations, viewing conditions and temperature
- (11) Results of testing with reference to acceptance criteria, location and size of reportable indications
- (12) Statement of acceptance / non-acceptance, evaluation date, name and signature of evaluator
- (13) Number of repairs if specific area repaired more than twice

8.3 In addition to generic items, reports of PT shall include the following specific items:

- (1) Type of penetrant, cleaner and developer used
- (2) Penetration time and development time

8.4 In addition to generic items, reports of MT shall include the following specific items:

- (1) Type of magnetization
- (2) Magnetic field strength
- (3) Detection media
- (4) Viewing conditions
- (5) Demagnetization, if required

8.5 In addition to generic items, reports of RT shall include the following specific items:

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

8.5.1 Examinations used for acceptance or rejection of welds shall be recorded in an acceptable medium. A written record providing following information: identification and description of welds, procedures and equipment used, location within recorded medium and results shall be included. The control of documentation unprocessed original images and digitally processes images is to be to the satisfaction of the surveyor.

8.6 In addition to generic items, reports of UT shall include the following specific items:

(1) Type and identification of ultrasonic equipment used (instrument maker, model, series number), probes (instrument maker, serial number), transducer type (angle, serial number and frequency) and type of couplant (brand).

- (2) Sensitivity levels calibrated and applied for each probe
- (3) Transfer loss correction applied Type of reference blocks
- (4) Signal response used for defect detection
- (5) Reflections interpreted as failing to meet acceptance criteria

8.6.1 The method for review and evaluation of UT reports is required for adequate quality control and is to be to the satisfaction of the surveyor.

8.7 The shipyard is to keep the inspection records specified in 8.2 to 8.6 of this document for at least for 5 years.

9 Unacceptable indications and repairs

9.1 Unacceptable indications shall be eliminated and repaired where necessary. The repair welds are to be examined on their full length using appropriate NDT method at the discretion of the Surveyor.

9.2 When unacceptable indications are found, additional areas of the same weld length shall be examined unless it is agreed with the surveyor and fabricator that the indication is isolated without any doubt. In case of automatic welded joints, additional NDT shall be extended to all areas of the same weld length.

All radiographs exhibiting non-conforming indications are to be brought to the attention of the surveyor. Such welds are to be repaired and inspected as required by the surveyor. When non-conforming indications are observed at the end of a radiograph, additional RT is generally required to determine their extent. As an alternative, the extent of non-conforming welds may be ascertained by excavation, when approved by the surveyor.

9.3 The extent of testing can be extended at the surveyor's discretion when repeated non-acceptable discontinuities are found.

9.4 The inspection records specified in section 8 are to include the records of repaired welds.

9.5 The Shipbuilder shall take appropriate actions to monitor and improve the quality of welds to the required level. The repair rate is to be recorded by the shipyard and any necessary corrective actions are to be identified in the builder's QA system.