



CHINA CLASSIFICATION SOCIETY

RULES FOR MATERIALS AND WELDING

AMENDMENTS

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PART ONE METALLIC MATERIALS

CHAPTER 1 GENERAL

Section 2 TESTING AND SURVEY

1.2.1 General requirements

1.2.1.1 Testing is to be carried out under the witness of the Surveyor, or an authorised deputy, in order to verify whether the test results meet the specified requirements.

~~1.2.1.24~~ The manufacturer is to provide the Surveyor with necessary facilities for access to all relevant parts of the works and necessary information so as to enable him to select the test materials, verify the calibration of inspection equipment, the accuracy of the testing and traceability of materials as required by the Rules and verify that manufacture is being carried out in accordance with the approved procedure specification and the quality of the products is maintained.

~~1.2.1.32~~ In the event of any material to be found and proved unsatisfactory during subsequent working, machining, fabrication or testing, such material is to be rejected, notwithstanding any previous certification.

1.2.2 Chemical composition

1.2.2.2 The method of sampling chemical composition is to follow that carried out for the initial approval tests, normally from the ladle, the tundish or the mould in the case of continuous casting. When multiple heats are tapped into a common ladle, the ladle analysis is to apply. The chemical composition is to be reported in percentage by weight.

1.2.2.3 The manufacturer's analysis may be accepted by CCS subject to occasional independent checks if required by the Surveyor. In case of doubt, the Surveyor may require to check the chemical composition of suitable samples from materials or products. For product samples, the permissible limits of deviation from the specified ladle analysis are to be in accordance with recognized standards.

1.2.8 Identification of materials

1.2.8.2 Accepted materials and products are to be marked with CCS stamp. For certain materials where hard stamping is impracticable, stenciling, painting or electric etching may be used. Paints used to identify alloy steels are to be free from harmful elements such as lead, copper, zinc or tin, etc. Coating used to identify austenitic stainless steels and austenitic/ferritic duplex stainless steels is to contain chloride content as low as possible. Small identical items of same type and dimensions that are packed in cases, casks or similar packages as well as steel bars and sections securely fastened together in bundles may be branded on the top of each bundle or package. Alternatively, a durable label giving the required particulars may be attached thereto.

CHAPTER 2 MATERIAL TESTS

Section 1 GENERAL PROVISIONS

2.1.3 Preparation of test specimens

2.1.3.5 Identification of all test specimens is to be made by the laboratory using appropriate numbering system to enable the tracing of specimen to its represented material. The identifying method is not to affect the test results.

Section 3 IMPACT TESTS

2.3.1 Impact test specimens

2.3.1.1 Impact test specimens are to be of the Charpy V-notch type, as shown in Figure 2.3.1.1. The dimensions and tolerances of the specimens are to comply with the requirements of Table 2.3.1.1.

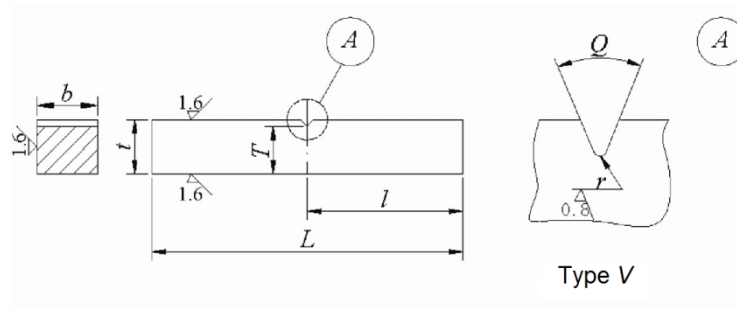


Figure 2.3.1.1

Dimensions of Impact Test Specimens

Table 2.3.1.1

Item	Designation	V-notch specimen	
		Nominal dimensions	Tolerance
Length (mm)	L	55	± 0.60
Width (mm)	Standard specimen	b	10
	Standard subsidiary specimen	b	7.5
		b	5
Thickness (mm)	t	10	$\pm 0.060.075$
Angle of notch (°)	Q	45	± 2
Width of notch (mm)	U	—	—
Depth below notch (mm)	T	8	$\pm 0.060.075$
Root radius (mm)	r	0.25	± 0.025
Distance of notch from end of test specimen (mm)	l	27.5	± 0.42
Angle between plane of symmetry of notch and longitudinal axis of test specimen (°)	—	90	± 2

CHAPTER 3 STEEL PLATES, FLAT-BARS AND SECTIONS

Section 1 GENERAL PROVISIONS

3.1.1.2 Where steels other than those specified in this Chapter are used, the chemical composition, deoxidation method, condition of supply and mechanical properties of the steels are to be submitted to CCS for approval.

3.1.2.6 It is the manufacturer's responsibility to ensure that effective process and production controls in operation are adhered to within the approved manufacturing specifications. Where deviation from the control and/or inferior quality of products exists, the manufacturer is to find the reasons and take measures to prevent it from reoccurrence. Meanwhile, a report is to be submitted to the Surveyor for information.

3.1.4 Preparation of specimens

3.1.4.3 For steel plates or flats ~~of thickness over 40 mm~~, the tensile specimens are generally to be prepared in such a manner as to maintain the rolling scale at least at one side ~~may be taken;~~ When the capacity of the test machine is exceeded by the use of a full thickness specimen or the product thickness exceeds 40 mm, sub-sized flat tensile specimens representing either the full thickness or half of the product thickness retaining one rolled surface are to be used. Alternatively, round cross-sectional specimens the axis of which is located as near as possible to 1/4 of the plate thickness may be used. ~~however, if round cross-sectional specimen is used, the axis of the specimen is to be located at 1/4 of the thickness of the product.~~

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 ~~prior to dispatch~~. 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.

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 ~~internal defects such as laminations or flaws~~. Segregations and non-metallic inclusions in the steel are as far as practicable to be minimized or eliminated.

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.

~~3.1.5.4~~ 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 of material does not absolve the steelmaker of the responsibility of ensuring the internal quality of the material.

3.1.6 Rectification of defects

3.1.6.1 For materials intended for structural purposes as detailed in Sections 2, 3, 4 and 6 of this

Chapter, 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;
- c) 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.

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 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; any occasional case where the defect depth exceed the above limit is subject to the special consideration of the Surveyor;
- (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 surface area;
- (3) two defects are considered as one defect where the distance between them is less than their average width;
- (4) elimination of the defect is proven by suitable non-destructive examination of the affected area;
- (5) 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;
- (6) if required by the Surveyor, the item is normalized or otherwise suitably heat-treated after welding and grinding.

3.1.7 Identification and certification of materials

3.1.7.1 Every finished item (small items may be fastened in bundles) is to be clearly marked, at least at one position, by the manufacturer with the CCS stamp and the following particulars:

- (1) the manufacturer's name or trade mark;
- (2) the grade of steel;
- (3) cast number and identification number or initials which will enable the full history of the item to be traced;
- (4) delivery condition of steels for structures (e.g. N, NR, TM, TM+AcC, TM+DQ or Q&T);
- (5) if required by the purchaser, his order number or other identification mark.

The above stamps and marks are to be encircled with paint for easy recognition.

3.1.7.3 The steelmaker is to provide certificates for all accepted materials in duplicate to the Surveyor. In addition to the name of the steelmaker, the certificate of conformity for steels is to include the following particulars:

- (1) purchaser's name and order number, and if known, the ship's name or machinery number for which the material is intended;
- (2) cast/piece number and chemical composition of ladle samples ~~address to which material is dispatched;~~
- (3) technical specification/grade ~~description~~ and dimensions of the material;
- (4) number and weight of the cargo;
- (5) ~~specification or grade of the steel;~~
- (6) ~~cast number and chemical composition of ladle samples,~~ carbon equivalent (Ceq, CET or Pcm value) (where applicable);
- (7) mechanical test results, including traceable test identification;
- (8) ~~condition of supply when other than as rolled (for high strength steels supplied in a heat treated condition in Section 4, the heat treatment temperature is to be attached);~~
- (9) surface quality and inspection results;
- (10) UT result, where applicable.

3.1.7.4 Before the certificates are signed by the Surveyor, the steelmaker is required to provide a written declaration stating that the material has been made by an approved process, and that it has been subjected to and has withstood satisfactorily the required tests in the presence of the Surveyor, or an authorized deputy. The declaration will be accepted if stamped or printed on each certificate with the name of the steelworks and signed by an authorized representative of the manufacturer.

3.1.7.5 When steel ingots or billets are not produced at works where they are rolled, a certificate of conformity is to be supplied by the steelmaker stating the process of manufacture, the cast number and the chemical composition of ladle samples. The works where the steel was produced is to be approved by CCS.

The whole Section 4 of Chapter 3 is replaced as follows:

Section 4 HIGH STRENGTH STEELS FOR WELDED STRUCTURES

3.4.1 Application

3.4.1.1 These requirements apply to hot-rolled, fine-grain, weldable high strength structural steels intended for use in marine and offshore structural applications. These requirements do not apply to steels intended for hull structures as specified in sections 2 and 3 of this Chapter.

The requirements of this Section may apply to products other than steel plates, such as sections or seamless tubulars, etc.

3.4.1.2 Steels covered by this section are specified in eight yield strength levels of 420, 460, 500, 550, 620, 690, 890 and 960 N/mm² based on the minimum required yield strength. For each yield strength level grades A, D, E and F are specified, based on the impact test temperature, except for yield strength level of 890 and 960 N/mm² for which grade F is not applicable.

The full list of grades is:

AH420	DH420	EH420	FH420
AH460	DH460	EH460	FH460
AH500	DH500	EH500	FH500
AH550	DH550	EH550	FH550

AH620	DH620	EH620	FH620
AH690	DH690	EH690	FH690
AH890	DH890	EH890	
AH960	DH960	EH960	

3.4.1.3 The requirements of this section apply to steel plates and flats with thickness not greater than 250 mm, the sections with thickness not greater than 50 mm and bars with diameter/thickness not exceeding 250 mm. Steels with a thickness beyond the maximum thickness as given above are to be subject to the special consideration of CCS.

3.4.1.4 Steels covered by this Section may be delivered in Normalized (N)/Normalized rolled (NR); Thermo-mechanical controlled rolled (TM) or Quenched and Tempered (QT) condition. TM delivery conditions may include Thermo-mechanical controlled rolled (TM), Thermo-mechanical controlled rolled with Accelerated cooling (TM+AcC) and Thermo-mechanical controlled rolled with direct quenching followed by tempering (TM+DQ).

3.4.1.5 Steels which have been specially approved by CCS and which differ from the requirements of the Rules are to have the letter “S” after the identification mark (e.g. EH620S).

3.4.2 Method of manufacture

3.4.2.1 The high strength steel specified by this Section is to be manufactured, by the basic oxygen, basic electric arc furnace or by processes specially approved by CCS.

3.4.2.2 Vacuum degassing is to be used for any of the following:

- (1) All steels with enhanced through-thickness properties (“Z” quality);
- (2) All steels of strength levels 690, 890 and 960 N/mm².

3.4.3 Deoxidation and chemical composition

3.4.3.1 The high strength steel as specified in this Section is to be fully killed, and is to be fine grain treated in accordance with an approved manufacturing process. A fine grain structure is to have an equivalent index ≥ 6 determined by micrographic examination in accordance with ISO 643 or alternative test method.

3.4.3.2 The aim analysis for chemical composition is to be carried out in accordance with the approved manufacturing specification. All elements listed in table 3.4.3.2 are to be reported. Steels of different delivery conditions are to meet the corresponding composition requirements.

Chemical Composition of High Strength Steels for Welded Structures Table 3.4.3.2

Delivery condition ^①	N/NR		TM		QT		
Steel grade	AH420 DH420 AH460 DH460	EH420 EH460	AH420 DH420 AH460 DH460 AH500 DH500 AH550 DH550 AH620 DH620 AH690 DH690 AH890	EH420 FH420 EH460 FH460 EH500 FH500 EH550 FH550 EH620 FH620 EH690 FH690 DH890 EH890 AH960	AH420 DH420 AH460 DH460 AH500 DH500 AH550 DH550 AH620 DH620 AH690 DH690 AH890 AH960	EH420 EH460 EH500 EH550 EH620 EH690 DH890 DH960	FH420 FH460 FH500 FH550 FH620 FH690 EH890 EH960
Chemical Composition ^②							
C (%)	≤0.20	≤0.18	≤0.16	≤0.14	≤0.18		

Mn (%)	1.0~1.70		1.0~1.70		≤1.70	
Si (%)	≤0.60		≤0.60		≤0.80	
P ^③ (%)	≤0.030	≤0.025	≤0.025	≤0.020	≤0.025	≤0.020
S ^③ (%)	≤0.025	≤0.020	≤0.015	≤0.010	≤0.015	≤0.010
Al(total) ^④ (%)	≥0.02		≥0.02		≥0.018	
Nb ^⑤ (%)	≤0.05		≤0.05		≤0.06	
V ^⑤ (%)	≤0.20		≤0.12		≤0.12	
Ti ^⑤ (%)	≤0.05		≤0.05		≤0.05	
Ni ^⑥ (%)	≤0.80		≤2.00 ^⑥		≤2.00 ^⑥	
Cu (%)	≤0.55		≤0.55		≤0.50	
Cr ^⑤ (%)	≤0.30		≤0.50		≤1.50	
Mo ^⑤ (%)	≤0.10		≤0.50		≤0.70	
N (%)	≤0.025		≤0.025		≤0.015	
O ^⑦ (ppm)	Not applicable		Not applicable	≤50	Not applicable	≤30

Notes: ① See 3.4.4.1 for definition of delivery conditions.

- ② The chemical composition is to be determined by ladle analysis and is to meet the approved manufacturing specification.
- ③ For sections the P and S content can be 0.005% higher than the value specified in the table.
- ④ The total aluminium to nitrogen ratio is to be a minimum of 2:1. When other nitrogen binding elements are used, the minimum Al value and Al/N ratio do not apply.
- ⑤ Total Nb+V+Ti ≤ 0.26% and Mo+Cr ≤ 0.65%, not applicable for QT steels.
- ⑥ Higher Ni content may be approved at the discretion of CCS.
- ⑦ The requirement on maximum Oxygen content is only applicable to DH890, EH890, DH960 and EH960.

3.4.3.3 Elements used for alloying, nitrogen binding, and fine grain treatment, and as well as the residual elements are to be as detailed in the manufacturing specification, e.g. when boron is deliberately added for enhancement of hardenability of the steels, the maximum content of the boron content is not to be higher than 0.005%, and the analysis result is to be reported.

3.4.3.4 The carbon equivalent value Ceq is to be calculated from the ladle analysis. Maximum values are specified in Table 3.4.3.4.

(1) For all steel grades the following formula of IIW may be used:

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

(2) For steel grades H460 and higher, CET may be used instead of Ceq at the discretion of the manufacturer, and is to be calculated according to the following formula:

$$CET = C + \frac{(Mn + Mo)}{10} + \frac{(Cr + Cu)}{20} + \frac{Ni}{40} (\%)$$

(3) For TM and QT steels with carbon content not more than 0.12%, the cold cracking susceptibility Pcm for evaluating weldability may be used instead of carbon equivalent of Ceq or CET at manufacturer's discretion and is to be calculated using the following formula:

$$Pcm = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B (\%)$$

Requirements for Carbon Equivalent of High Strength Steel (%) Table 3.4.3.4

Carbon Equivalent (%)	<i>Ceq</i>						<i>CET</i>	<i>Pcm</i>
Product form	Plates			Sections	Bars	Tubulars	all	all
Thickness								
Steel grade and delivery condition	t≤50 (mm)	50<t≤100 (mm)	100<t≤250 (mm)	t≤50 (mm)	T(or d) ≤250 (mm)	t≤65 (mm)	all	all
H420N/NR	0.46	0.48	0.52	0.47	0.53	0.47	-	
H420TM	0.43	0.45	0.47	0.44	-	-		
H420QT	0.45	0.47	0.49	-	-	0.46		
H460N/NR	0.50	0.52	0.54	0.51	0.55	0.51	0.25	
H460TM	0.45	0.47	0.48	0.46	-	-	0.30	0.23
H460QT	0.47	0.48	0.50	-	-	0.48	0.32	0.24
H500TM	0.46	0.48	0.50	-		-	0.32	0.24
H500QT	0.48	0.50	0.54			0.50	0.34	0.25
H550TM	0.48	0.50	0.54			-	0.34	0.25
H550QT	0.56	0.60	0.64			0.56	0.36	0.28
H620TM	0.50	0.52	-			-	0.34	0.26
H620QT	0.56	0.60	0.64			0.58	0.38	0.30
H690TM	0.56	-				-	0.36	0.30
H690QT	0.64	0.66	0.70			0.68	0.40	0.33
H890TM	0.60	-				-	0.38	0.28
H890QT	0.68	0.75	-			-	0.40	-
H960QT	0.75	-				-	0.40	-

Note: “-” = Not applicable.

3.4.4 Delivery condition

3.4.4.1 High strength steel specified in this Section is to be delivered in accordance with the following condition:

- (1) Normalized (N)/Normalized rolled (NR);
- (2) Thermo-mechanical controlled rolled (TM), including TM+AcC and TM+DQ;
- (3) Quenched and Tempered condition (QT) (including direct quenching after hot-rolling followed by tempering).

3.4.5 Rolling reduction ratio

3.4.5.1 The rolling reduction ratio of slab, billet, bloom or ingot is not to be less than 3:1 unless agreed at the time of approval.

3.4.6 Thickness limits

3.4.6.1 The maximum thickness of slab, billet or bloom from the continuous casting process is to be at the manufacturer’s discretion.

3.4.6.2 Maximum thickness of plates, sections, bars and tubulars over which a specific delivery condition is applicable are shown in Table 3.4.6.2.

Maximum thickness limits for Different Forms of Products Table 3.4.6.2

Delivery condition	Maximum thickness/diameter (mm)			
	Plates	Sections	Bars	Tubulars
N	250 ^②	50	250	65

Delivery condition	Maximum thickness/diameter (mm)			
	Plates	Sections	Bars	Tubulars
NR	150	①		
TM	150	50	Not applicable	Not applicable
QT	150 ^②	50	Not applicable	50

Notes: ① The maximum thickness limits of sections, bars and tubulars produced by NR process route are generally less than those manufactured by N route, and is to be at the discretion of CCS.

② Approval for N steels with thickness larger than 250 mm and QT steels with thickness larger than 150 mm is subject to the special consideration of CCS.

3.4.7 Mechanical properties

3.4.7.1 Test frequency for mechanical properties is to meet the following requirements:

(1) Tensile test sample is to be randomly selected from each batch, that is to be less than or equal to 25 tonnes, and to be from the same cast, in the same delivery condition and of the same thickness.

(2) Charpy V-notch impact test specimens are to be taken in accordance with following requirements:

- For steel plates or flats in N, NR or TM condition test sample is to be taken from each piece.
- For steel plates or flats in QT condition test sample is to be taken from each individually heat treated part thereof.
- For sections, bars and tubulars, test sample is to be taken from each batch of 25 tonnes or fraction thereof.

(3) For continuous heat treated product special consideration may be given to the number and location of impact test specimens required by the manufacturer to be agreed by CCS.

3.4.7.2 In addition to the following requirements, the position and direction of the specimens taken for mechanical property tests are to be in accordance with the relevant requirements of 3.1.4 of this chapter.

(1) Where round cross-sectional tensile specimens are used for the steel with thickness above 100 mm, the specimens are to be located at a position lying at a distance of $t/4$ from the surface and additionally at $t/2$.

(2) The Charpy V-notch impact test specimens for plates and wide flats over 600 mm in width are to be taken with their axes transverse to the final rolling direction; for other product forms, the impact tests are to be in the longitudinal direction.

(3) Sub-surface impact test specimens will be taken in such a way that one side is not further away than 2 mm from a rolled surface, however, for material with a thickness in excess of 50 mm, impact test specimens shall be taken at the quarter thickness ($t/4$) location and mid-thickness ($t/2$).

(4) Impact test for a nominal thickness less than 6 mm is normally not required.

3.4.7.3 Test specimens and test procedures for mechanical properties are to be in accordance with the provisions of Chapter 2 of the Rules.

3.4.7.4 The results of the tests are to comply with the appropriate requirements of Table 3.4.7.4. In the case of product forms other than plates and wide flats where longitudinal tests are agreed, the elongation values are to comply with the longitudinal requirements as listed in Table 3.4.7.4.

Mechanical properties of High Strength Steels for Welded Structures Table 3.4.7.4

Mechanical properties Steel Grade & delivery condition		Minimum yield strength R_{eH} (N/mm ²)			Ultimate tensile strength R_m (N/mm ²)		Minimum percentage elongation after fracture A_5 (%) $L_0=5.65\sqrt{S_0}$		Charpy V-notch impact test		
		Nominal thickness (mm)			Nominal thickness (mm)				Test temp (°C)	Minimum impact energy (J)	
		≥3 ≤50	>50 ≤ 100	>100 ≤250 ^①	≥3 ≤100	>100 ≤250 ^①	T	L		T	L
H420N/NR H420TM H420QT	A D E F	420	390	365	520~680	470~650	19	21	0 -20 -40 -60	28	42
H460N/NR H460TM H460QT	A D E F	460	430	390	540~720	500~710	17	19	0 -20 -40 -60	31	46
H500TM H500QT	A D E F	500	480	440	590~770	540~720	17	19	0 -20 -40 -60	33	50
H550TM H550QT	A D E F	550	530	490	640~820	590~770	16	18	0 -20 -40 -60	37	55
H620TM H620QT	A D E F	620	580	560	700~890	650~830	15	17	0 -20 -40 -60	41	62
H690TM H690QT	A D E F	690	650	630	770~940	710~900	14	16	0 -20 -40 -60	46	69
H890TM H890QT	A D E	890	830	Not applica ble	940~1100	Not applicable	11	13	0 -20 -40	46	69
H960QT	A D E	960	Not applica ble	Not applica ble	980~1150	Not applicable	10	12	0 -20 -40	46	69

Note: ① For plates and sections for applications, such as racks in offshore platforms etc., where the design requires that tensile properties are maintained through the thickness, a decrease in the minimum specified tensile properties is not permitted with an increase in the thickness.

3.4.7.5 For full thickness flat test specimens with a width of 25 mm and a gauge length of 200 mm the elongation is to comply with the minimum values shown in Table 3.4.7.5.

Elongation Minimum Values for Full Thickness Flat Test Specimens^① Table 3.4.7.5

Strength level	Thickness (mm)						
	≤10	>10 ≤15	>15 ≤20	>20 ≤25	>25 ≤40	>40 ≤50	>50 ≤70
H420	11	13	14	15	16	17	18
H460	11	12	13	14	15	16	17
H500	10	11	12	13	14	15	16
H550	10	11	12	13	14	15	16
H620	9	11	12	12	13	14	15
H690	9 ^②	10 ^②	11 ^②	11	12	13	14

Notes: ① The tabulated elongation minimum values are the requirements for testing specimen in transverse

direction.

- ② For H690 plates with thickness ≤ 20 mm, round specimen in accordance with Section 2, Chapter 2 of this PART may be used instead of the flat tensile specimen. The minimum elongation for testing specimen in transverse direction is 14%.
- ③ H890 and 960 specimens and specimens which are not included in this table are to be proportional specimens with a gauge length of $L_0=5.65\sqrt{S_0}$.

3.4.7.6 For steels designated with improved through thickness properties (“Z” quality), tests are to be performed in accordance with Section 10 of this Chapter. Through thickness tensile strength is not to be less than 80% of the specified minimum tensile strength.

3.4.8 Stress relieving heat treatment and other heat treatments

3.4.8.1 Steels approved with respect to heat treatment are suitable for stress relieving heat treatment such as post-weld heat treatment and stress relieving heat treatment after cold forming for the purpose of reducing the risk of brittle fracture, increasing the fatigue lifetime and dimensional stability for machining.

Section 12 ROLLED STEEL BARS FOR ANCHOR CHAIN CABLES AND ACCESSORIES

3.12.3 Manufacture

3.12.3.2 The steels intended for chain cables and mooring chains are to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved.

3.12.3.4 Grade ~~MR3S, MR4~~, MR4S and MR5 mooring chain steels are to be vacuum degassed.

3.12.4 Chemical analysis and metallurgical examination

3.12.4.2 For offshore mooring chain steels, a metallographic sample from each ladle is to be taken and measurements for circular sections are to be taken at 1/3 radius to examine the austenitic grain size according to a recognized standard (e.g. ASTM E112). The austenitic grain size is to be 6 or finer.

3.12.4.3 ~~With a view to providing information f~~For steels of grades MR4S and MR5, the following information is to be supplied by the bar manufacturer to the mooring chain manufacturer and the results included in the chain documentation ~~a sample from each heat is to be taken and examined according to a recognized standard by the manufacturer as follows:~~

(1) Non-metallic inclusions: non-metallic inclusions of each heat are ~~The level of micro inclusions is~~ to be quantified and assessed in accordance with a recognized standard (e.g. ISO 4967), to be sure inclusion levels are acceptable for the final product.

(2) Macro etching: a sample from each heat is to be macro etched according to a recognized standard (e.g. ASTM E381), to be sure there is no injurious segregation or porosity.

(3) Hardenability: a sample from each heat is to be tested in accordance with a recognized

standard (e.g. ASTM A255) ~~the test is to be recorded in the report.~~

3.12.5 Mechanical tests

3.12.5.2 A tensile specimen is to be taken from the test sample. Except for grade M1 chain steels, a set of three Charpy V-notch impact specimens are to be taken from the same test sample. The tensile and impact specimens are to be taken from the sample in the longitudinal direction at a position of 1/6 diameter from the surface or as close as possible to this position, as shown in Figure 3.12.5.2a or b. The preparation and dimensions of specimens are to comply with the relevant requirements of Chapter 2 of this PART. The cross-sectional area of the tensile specimen is in general not to be less than 150 mm². Where the cross-sectional area of the sample is not sufficient for taking these specimens, the tensile specimen in full cross section may also be taken.

The tensile and impact tests and retests are to be carried out in compliance with the relevant requirements of Chapter 2 of this PART and test results are to comply with the requirements of Table 3.12.5.2.

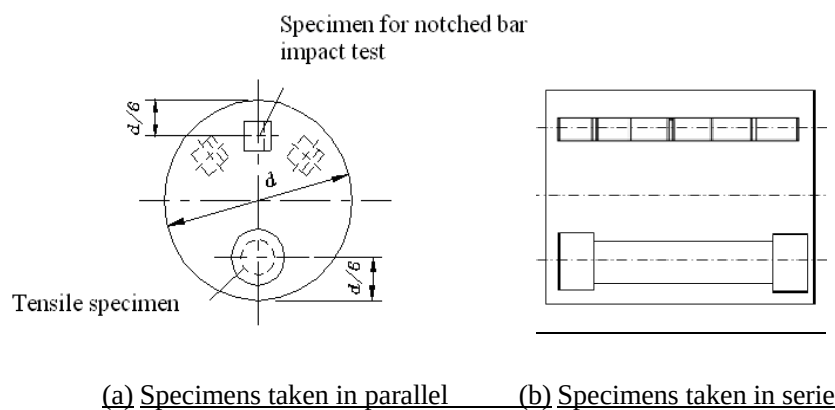


Figure 3.12.5.2 Position of Taking Specimens

Mechanical Properties of Material Intended for Chain Cables, Mooring Cables and Accessories

Table 3.12.5.2

Grade	Yield point R_{eH} (N/mm ²)	Tensile strength R_m (N/mm ²)	Elongation A_5 (%)	Reduction of area Z (%)	Charpy V-notch impact test	
					Test temperature (°C)	Impact energy (J)
M1	Not required	370 ~ 490	≥ 25	Not required	Not required	Not required
M2	≥ 295	490 ~ 690	≥ 22	Not required	0	≥ 27 ^①
M3	≥ 410	≥ 690	≥ 17	40	0(-20) ^②	≥ 60(35)
MR3	≥ 410 ^③	≥ 690 ^③	≥ 17	50	0(-20) ^②	≥ 60(40)
MR3S	≥ 490 ^③	≥ 770 ^③	≥ 15	50	0(-20) ^②	≥ 65(45)
MR4	≥ 580 ^③	≥ 860 ^③	≥ 12	50	-20	≥ 50
MR4S ^④	≥ 700 ^③	≥ 960 ^③	≥ 12	50	-20	≥ 56

Grade	Yield point R_{eH} (N/mm ²)	Tensile strength R_m (N/mm ²)	Elongation A_5 (%)	Reduction of area Z (%)	Charpy V-notch impact test	
					Test temperature (°C)	Impact energy (J)
MR5 ^④	≥ 760 ^③	≥ 1000 ^③	≥ 12	50	-20	≥ 58

Notes: ① The impact test for Grade M2 steel may be waived if the steel is to be supplied in a heat treated condition.

② Normally, the temperature of impact test for Grades M3, MR3 and MR3S steel is 0°C. If required by the purchaser, -20°C may be regarded as a supply condition.

③ ~~The yield to tensile ratio is generally not to be greater than 0.92.~~ Aim value of yield to tensile ratio: 0.92 max.

④ Maximum hardness for MR4S is to be 330HBW and for MR5 to be 340HBW.

3.12.5.3 In addition, each heat of Grade MR3S, MR4, MR4S and MR5 steel bars is to be tested for hydrogen embrittlement as follows:

(1) In case of continuous casting, test samples representing both the beginning and the end of the charge are to be taken. In case of ingot casting, test samples representing two different ingots are to be taken.

(2) Two (2) tensile test specimens are to be taken from the central region of bar material which has been subjected to the heat treatment cycle intended to be used in production. A specimen with a diameter of 20 mm (or 14 mm) is preferred.

(3) One of the specimens is to be tested within a maximum of 3 h after machining (for a 14 mm diameter specimen, the time limit is 1.5 h). Where this is not possible, the specimen is to be immediately cooled to -60°C after machining and kept at that temperature for a maximum period of 5 days. The second specimen is to be tested after baking at 250°C for 4 h, alternatively 2 h for 14 mm diameter specimen.

(4) A slow strain rate $< 0.0003 \text{ s}^{-1}$ must be used during the entire test, until fracture occurs (this is approximately 10 min for the 20 mm diameter specimen).

(5) Tensile strength, elongation and reduction of area are to be reported. The acceptance requirement for the test is:

$$Z_1/Z_2 \geq 0.85$$

where: Z_1 = Reduction of area without baking;

Z_2 = Reduction of area after baking.

If the requirement $Z_1/Z_2 \geq 0.85$ is not achieved, the bar material may be subjected to a hydrogen degassing treatment after agreement with CCS. New tests are to be performed after degassing.

3.12.5.4 Failure to meet the requirements will result in rejection of the batch represented, unless it can be clearly attributable to improper simulated heat treatment and the material may be presented for retest after another heat treatment.

3.12.6 Surface quality and tolerances

3.12.6.2 Unless otherwise specified in the contract, the tolerances of diameter and roundness of steel bars directly used for welding chain cables or mooring chains are to be in compliance with the requirements of Table 3.12.6.2. For steels intended for mooring chains, at least 1% of a batch of steel bars are to be sampled for roundness measurement. The roundness is to be taken by measuring the maximum and minimum diameters at a cross section. The tolerance on roundness is

the difference between them.

Tolerance of Diameter and Roundness for Steel Bars

Table 3.12.6.2

Nominal diameter (mm)	< 25	25 ~ 35	36 ~ 50	51 ~ 80	81 ~ 100	101 ~120	121 ~160	161 ~210	222
Tolerance on diameter (mm)	-0~+1.0	-0~+1.2	-0~+1.6	-0~+2.0	-0~+2.6	-0~+3.0	-0~+4.0	-0~ + 5.0	
Tolerance on roundness (mm)	0.6	0.8	1.1	1.5	1.95	2.25	3.00	4.00	

3.12.7 Non-destructive examination and repair

3.12.7.1 Non-destructive examination procedures for the bar material intended for either mooring chain or fittings are to be developed by the bar supplier and submitted together with acceptance criteria to CCS for information at the time of approval.

3.12.7.2 100 percent of bar material intended for either mooring chain or fittings is to be subjected to ultrasonic examination at an appropriate stage of the manufacture in accordance with procedures and acceptance criteria confirmed at the time of approval. The bars are to be free of pipe, cracks and flakes. If the end length of the delivered bars is not subjected to UT then it must be agreed between the bar supplier and the chain manufacturer of what length of bar is to be removed from the ends. The details are to be documented in the approval of each bar supplier. Phased array UT procedures may be applied, subject to approval by CCS.

3.12.7.3 100 percent of the bar material intended for offshore mooring chains is to be examined by magnetic particles, eddy current or magnetic leakage flux testing or an equivalent method. Non-destructive examination of surface is to be performed in accordance with recognized standards (e.g. ISO 9934, ISO 15549 etc.). The bars are to be free of injurious surface imperfections such as seams, laps and rolled-in mill scale. Provided that their depth is not greater than 1% of the bar diameter, longitudinal discontinuities may be removed by grinding and blending to a smooth contour.

~~3.12.7.3 Non-destructive examination is to be performed in accordance with recognized standards. Non-destructive examination procedures together with rejection/acceptance criteria are to be submitted to CCS for information.~~

3.12.7.4 All bars supplied in a machined (peeled) condition are to be 100% visually inspected. CCS may also require: 10% inspected with magnetic particle testing (MT) or eddy current testing (ET) or Magnetic Leakage Flux Testing (MLFT), for longitudinal imperfections. The maximum depth of peeling is to be agreed and documented in the approval of each supplier.

3.12.7.5 The frequency of non-destructive examinations may be reduced at the discretion of CCS provided it is demonstrated by statistical means that the quality of products is consistently kept above the required level.

3.12.7.6 Weld repair of bar intended for mooring chain is not permitted.

3.12.8 Marking and certification

3.12.8.2 Each batch of bars is to be furnished with a certificate of conformity signed by CCS Surveyor. The certificate is to contain particulars required by 3.1.7.3 of this Chapter and, when the simulated heat treatment required for the finished chain cables is carried out to specimens

according to 3.12.5.1 of this Section, details of heat treatment of specimens, number of specimens and the corresponding mechanical test results. Additionally for Grade MR3S, MR4, MR4S and MR5 bars intended for mooring chains, the certificate is to contain the results of hydrogen embrittlement test, non-destructive examination, etc., and the information of austenitic grain size, non-metallic inclusions and hardenability.

CHAPTER 4 STEEL PIPES AND TUBES

Section 1 GENERAL PROVISIONS

4.1.1 Application

4.1.1.1 The requirements of this Section apply to boiler tubes and superheater tubes, and pipes intended for use in the construction of boilers, pressure vessels and pressure piping systems.

4.1.1.2 For steel tubes subject to elevated working temperatures, details of appropriate mechanical properties at elevated temperatures are to be submitted to CCS for approval.

4.1.1.3 In addition to the requirements of Chapters 1 and 2 of this PART, all pipes and tubes (except Class III pipes) are to be manufactured and tested in accordance with the provisions of relevant Sections of this Chapter (for the grades of piping involved in this Chapter, reference is made to the relevant requirements in Chapter 2 of PART THREE of CCS Rules for Classification of Sea-going Steel Ships).

4.1.1.4 Pipes and tubes for Class III piping systems may be manufactured, tested and accepted in accordance with relevant recognized standards.

4.1.1.5 Pipes and tubes for submarine piping systems may be manufactured, tested and accepted in accordance with relevant recognized standards.

4.1.1.6 Impact tests for the piping systems (including pipes, valves and fittings) of polar ship which are exposed to low air temperature environments are to satisfy the relevant requirements of Chapter 23, PART EIGHT of Rules for Classification of Sea-going Steel Ships.

CHAPTER 5 STEEL FORGINGS

Section 1 GENERAL PROVISIONS

5.1.1 Application

5.1.1.1 This Chapter applies to steel forgings intended for use in the construction of ships, machinery, pressure vessels and piping systems, which are to be manufactured in accordance with 3.1.2.2 and 3.1.2.3 of this PART. Where it is proposed to use carbon or carbon-manganese steels or alloy steels other than those specified in this Chapter, details of the chemical composition, mechanical properties and heat treatment process are to be submitted to CCS for approval, and such steels, subject to agreement of CCS, may be accepted in accordance with the relevant recognized standards.

5.1.1.2 Impact tests for the steel forgings of polar ship which are exposed to low air temperature environments are to satisfy the relevant requirements of Chapter 23, PART EIGHT of Rules for Classification of Sea-going Steel Ships.

5.1.1.23 The requirements of this Chapter are also applicable to rolled slabs and billets used as a substitute for forgings and to rolled bars used for the manufacture (by machining operations only) of shafts, bolts, studs and other components of similar shape.

5.1.1.43 Forgings are to be made at works which have been approved by CCS. The steel used is to be manufactured at steel works approved by CCS.

CHAPTER 6 STEEL CASTINGS

Section 1 GENERAL PROVISIONS

6.1.1 Application

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

6.1.1.2 Impact tests for the steel castings of polar ship which are exposed to low air temperature environments are to satisfy the relevant requirements of Chapter 23, PART EIGHT of Rules for Classification of Sea-going Steel Ships.

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

~~6.1.1.4~~ Where it is proposed to use carbon or carbon-manganese steels or alloy steels other than those specified in this Chapter, details of the chemical composition, heat treatment process and mechanical properties, etc., when agreed by CCS, may be accepted in accordance with the relevant recognized standards.

~~6.1.1.5~~ Small castings less than 1 t in mass and made from the same cast with the similar size and heat treated in the same furnace charge may be submitted for testing in batches of not greater than 6 t, subject to agreement of CCS.

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, but ~~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.~~

6.1.6.4 The test specimens are to be taken where the axis is at 1/4 of thickness of test samples. Where the thickness of test samples is less than 56 mm, the axis of test specimens is to be taken at 14 mm from the surface. All test specimens are to be prepared in accordance with the requirements of Chapter 2 of this PART. Tensile test specimens are to have a cross-sectional area of not less than 150 mm².

Section 2 CASTINGS FOR HULL STRUCTURES

6.2.3 Heat treatment

6.2.3.1 Castings are to be heat treated as follows:

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

6.2.4.3 The castings of primary hull structures (i.e. stem, stern frame, rudder bearing, propeller shaft bracket, rudder horn, stern tube shaft, etc.) are to be subject to Charpy V-notch impact tests. The test specimens are to be taken at t/4 from the surface of the sample. ~~In general, the impact test is to be carried out at ambient temperature. If the structure is required to be strengthened for ice, the test temperature is to be 0°C. The impact energy is to be not less than 27 J.~~

CHAPTER 8 ALUMINIUM ALLOYS

Section 2 ALUMINIUM ALLOY PLATES AND SECTIONS

Chemical Composition of Aluminum Alloys (%)

**Table
8.2.3.1**

Designation	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al	Other elements ^①	
										Each	Total
5A01	Si+Fe≤0.40		≤0.10	0.30~0.70	6.0~7.0	0.10~0.20	≤0.20	≤0.15	Residual	≤0.05	≤0.15
5454	≤0.25	≤0.40	≤0.10	0.50~1.0	2.4~3.0	0.05~0.20	≤0.25	≤0.20	Residual	≤0.05	≤0.15
5083	≤0.40	≤0.40	≤0.10	0.40~1.0	4.0~4.9	0.05~0.25	≤0.25	≤0.15	Residual	≤0.05	≤0.15
5383	≤0.25	≤0.25	≤0.20	0.7~1.0	4.0~5.2	≤0.25	≤0.40	≤0.15	Residual	≤0.05 ^④	≤0.15 ^④
5059	≤0.45	≤0.50	≤0.25	0.6~1.2	5.0~6.0	≤0.25	0.40~0.90	≤0.20	Residual	≤0.05 ^⑤	≤0.15 ^⑤
5086	≤0.40	≤0.50	≤0.10	0.20~0.70	3.5~4.5	0.05~0.25	≤0.25	≤0.15	Residual	≤0.05	≤0.15
5456	≤0.25	≤0.40	≤0.10	0.50~1.0	4.7~5.5	0.05~0.20	≤0.25	≤0.20	Residual	≤0.05	≤0.15
5754	≤0.40	≤0.40	≤0.10	≤0.50 ^②	2.6~3.6	≤0.30 ^③	≤0.20	≤0.15	Residual	≤0.05	≤0.15
6005A	0.50~0.90	≤0.35	≤0.30	≤0.50 ^③	0.4~0.7	≤0.30 ^③	≤0.20	≤0.10	Residual	≤0.05	≤0.15
6061	0.40~0.80	≤0.7	0.15~0.40	≤0.15	0.8~1.2	0.04~0.35	≤0.25	≤0.15	Residual	≤0.05	≤0.15
6082	0.7~1.3	≤0.50	≤0.10	0.40~1.0	0.6~1.2	≤0.25	≤0.20	≤0.10	Residual	≤0.05	≤0.15

Notes: ① Other elements include Ni, Ga, V and listed elements for which no specific limit is shown. Regular analysis need not be made.

② $0.10\% \leq \text{Mn} + \text{Cr} \leq 0.60\%$.

③ $0.12\% \leq \text{Mn} + \text{Cr} \leq 0.50\%$.

④ $\text{Zr} \leq 0.20$. The total for other elements does not include zirconium (Zr).

⑤ $0.05\% \leq \text{Zr} \leq 0.25\%$. The total for other elements does not include zirconium.

8.2.5.11 The manufacturers are in general to establish the relationship between microstructure and resistance to corrosion when the above alloys are approved. A reference photomicrograph taken at 500x, under the conditions specified in ASTM B928, Section 9.4.1, is to be established for each of the alloy-temper and thickness ranges relevant. The reference photographs are to be taken from samples which have exhibited no evidence of exfoliation corrosion and a pitting rating of PB or better, when subjected to the test described in ASTM G667 (ASSET). The samples are also to have exhibited resistance to intergranular corrosion at a mass loss no greater than 15 mg/cm², when subjected to the test described in ASTM G676 (NAML). Upon satisfactory establishment of the relationship between microstructure and resistance to corrosion, the master photomicrographs and the results of the corrosion tests are to be approved by CCS. Production practices are not to be changed after approval of the reference micrographs.

8.2.5.12 For batch acceptance of aluminium alloy (5xxx) alloys in the H116 and H321 tempers, metallographic examination of one sample selected from mid width at one end of a coil or random sheet or plate is to be carried out. The microstructure of the sample is to be compared to the reference photomicrograph of acceptable material in the presence of the Surveyor. A longitudinal section perpendicular to the rolled surface is to be prepared for metallographic examination, under

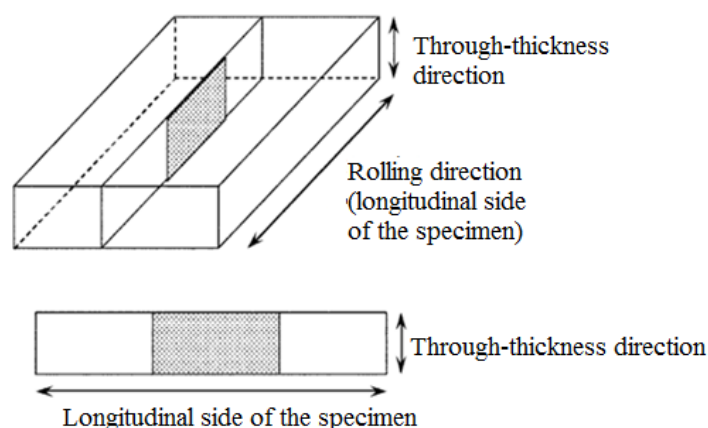
the conditions specified in ASTM B928, Section 9.6.1. If the microstructure shows evidence of continuous grain boundary network of aluminium-magnesium precipitate in excess of the reference photomicrographs of acceptable material, the batch is either to be rejected or tested for ~~intergranular exfoliation~~ corrosion resistance and ~~exfoliation intergranular~~ corrosion resistance subject to agreement of the Surveyor. The corrosion tests are to be in accordance with ASTM G66 and G67 or equivalent standards. Acceptance criteria are that the sample is to exhibit no evidence of exfoliation corrosion and a pitting rating of PB or better when subjected to ASTM G667 ASSET test, and the sample is to exhibit resistance to intergranular corrosion at a mass loss no greater than 15 mg/cm² when subjected to ASTM G667 NAML T test. If the results from testing satisfy the acceptance criteria stated in paragraph 8.2.5.11, the batch is accepted, else it is to be rejected.

8.2.5.13 As an alternative to metallographic examination, each batch may be tested for ~~intergranular exfoliation~~ corrosion resistance and ~~exfoliation intergranular~~ corrosion resistance, in accordance with ASTM G66 and G67 under the conditions specified in ASTM B928. If this alternative is used, then the results of the test are to satisfy the acceptance criteria stated in paragraph 8.2.5.12.

8.2.6.5 For corrosion test or metallographic examination, ~~test specimen is to be taken as shown in Figure 8.2.6.5 with its~~ a longitudinal section perpendicular to the rolled surface ~~and is to be~~ prepared as follows:

- (1) from mid width at one end of a coil;
- (2) from mid width at one end of a random sheet or plate.

The sampling direction and evaluation areas of intergranular corrosion specimen are shown in Figure 8.2.6.5.



The dash areas in the Figure are the ~~corrosion and~~ evaluation areas of intergranular corrosion specimen respectively

Figure 8.2.6.5 Sampling Direction and Evaluation Areas of Intergranular of Corrosion Specimen

CHAPTER 10 EQUIPMENT

Section 3 OFFSHORE MOORING CHAINS AND ACCESSORIES

10.3.1 Application

10.3.1.2 The mooring chains specified in this Section include common stud and studless links, connecting common links (splice links), enlarged links, end links, detachable connecting links (~~Kenter~~ shackles), end shackles, subsea connectors, swivels and swivel shackles.

10.3.3 Material

10.3.3.2 Forged steels used for the manufacture of accessories are to comply with the relevant requirements of Section 1, Chapter 5 of this PART, unless otherwise specified as follows:

(1) Forged steels are to comply with the approved specifications and the submitted test reports approved by CCS. Steel is to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steel is to be killed and fine grain treated. Steel for forgings intended for R4S and R5 chain is to be vacuum degassed. The austenitic grain size is to be 6 or finer.

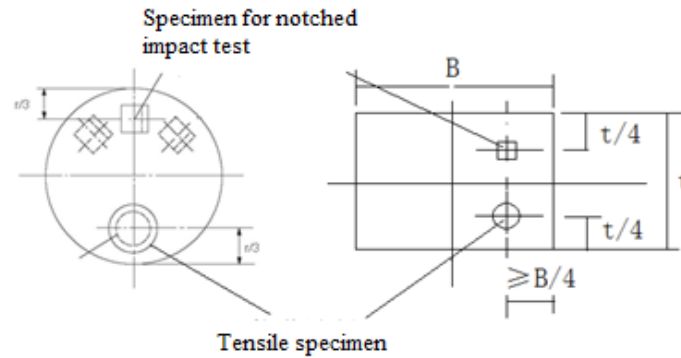
(2) The steel manufacturer is to determine the chemical composition of every heat of material. The chemical composition is to comply with the specifications acceptable to CCS at the time of approval.

(3) Steel for forgings is to be tested for the austenitic grain size in accordance with a recognized standard (e.g. ASTM E112). The austenitic grain size is to be 6 or finer. Measurements for circular sections are to be taken at 1/3 radius. Measurements for non-circular sections are to be taken at 1/4t.

(4) For steel intended for R4S and R5 accessories, each heat is to be subject to the quantification and assessment of non-metallic inclusions in accordance with the national/international standards (e.g. ISO 4967), examination of segregation or porosity (e.g. ASTM E381) and testing of hardenability (e.g. ASTM A255). The results are to satisfy the requirements determined at the time of approval.

(35) Finished forgings are to be properly heat treated in compliance with the specifications submitted and approved.

(46) After proper heat treatment, Forgings of similar dimensions (diameters do not differ by more than 25 mm) originating from the same heat treatment charge and the same heat of steel are to be combined into one test unit, and from each test unit one sample is to be taken. One tensile and three impact test specimens are to be taken from the sample at the locations as shown in Figure 3.12.5.2 Figure 10.3.8.8(1) of Section 12, Chapter 3 of this PART and or Figure 10.3.3.2(4) of this Section for mechanical testing. The mechanical properties are not to be inferior to those required for steel bars intended for mooring chains in Section 12, Chapter 3 of this PART.



a Sampling positions of specimen with circular section b Sampling positions of specimen with rectangular section

Figure 10.3.3.2(4) Sampling Position of Specimens for Mechanical Testing

(7) Each heat of Grade R3S, R4, R4S and R5 is to be tested for hydrogen embrittlement in accordance with the requirements of 3.12.5.3, Section 12, Chapter 3 of this PART.

(8) Wet continuous magnetization technique by adopting recognized standards (e.g. EN 10228-1 or other equivalent standards) is to be used for testing of the surface of delivered steel forgings in accordance with the testing procedure submitted by the manufacturer. All The forgings are to be subject to one hundred percent ultrasonic examination at an appropriate stage of manufacture in compliance with ~~an approved~~ a recognized standard (e.g. ISO 13588 or other equivalent standards). The testing results are to satisfy the requirements of standards submitted at the time of approval.

(9) Defects on non-machined surfaces of forging materials intended for mooring chains may be removed by grinding to a depth of 5% of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces to a maximum depth of 0.8 mm in order to investigate spurious indications. Welding repairs are not permitted.

10.3.3.3 Cast steels used for the manufacture of accessories (anchor shackles) are to comply with the relevant requirements of Section 1, Chapter 6 of this PART, unless otherwise specified as follows:

(1) Cast steels are to comply with the approved specifications and the submitted test reports approved by CCS. Steel is to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steel is to be killed and fine grain treated. Steel for forgings intended for R4S and R5 chain is to be vacuum degassed. ~~The austenitic grain size is to be 6 or finer.~~

(2) The manufacturer is to determine the chemical composition of every heat. The chemical composition is to comply with the specifications acceptable to CCS at the time of approval.

(3) Steel for castings is to be tested for the austenitic grain size in accordance with a recognized standard (e.g. ASTM E112). The austenitic grain size is to be 6 or finer. Measurements for circular sections are to be taken at 1/3 radius. Measurements for non-circular sections are to be taken at

1/4t.

(4) For steel forgings intended for R4S and R5 accessories, each heat is to be subject to the quantification and assessment of non-metallic inclusions, examination of segregation or porosity and testing of hardenability in accordance with the national/international standards (e.g. ISO 4967, ASTM E381 and ASTM A255). The results are to satisfy the requirements determined at the time of approval.

(53) All castings are to be properly heat treated in compliance with specifications submitted and approved.

(64) Castings of similar dimensions originating from the same heat treatment charge and the same heat of steel are to be combined into one test unit, and from each test unit one sample is to be taken. One tensile and three impact test specimens are to be taken from the sample at the locations as shown in Figure 40.3.8.8(1)3.12.5.2 of Section 102, Chapter 3 of this PART for mechanical testing. The mechanical properties are not to be inferior to those required for steel bars intended for mooring chains in Section 12, Chapter 3 of this PART. The acceptance requirement for reduction of area is, however, reduced to 40% for grades R3 and R3S and 35% for grades R4, R4S and R5.

(57) Wet continuous magnetization technique by adopting recognized standards (e.g. ASTM E709 or other equivalent standards) is to be used for testing of the surface of delivered castings in accordance with the testing procedure submitted by the manufacturer. The forgings are to be subject to one hundred percent ultrasonic examination at an appropriate stage of manufacture in compliance with a recognized standard (e.g. ISO 13588 or other equivalent standards). The testing results are to satisfy the requirements of standards submitted at the time of approval.

(8) Defects on non-machined surfaces may be removed by grinding to a depth of 5% of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces to a maximum depth of 0.8 mm in order to investigate spurious indications. Where the repair entails removal of more than 5% of the diameter or thickness, the defective area is to be repaired by welding in accordance with the following requirements:

- ① The excavations are to be suitably shaped to allow good access for welding. The resulting grooves are to be subsequently ground smooth and complete elimination of the defective material is to be verified by NDE.
- ② A weld repair is considered major when the depth of the groove prepared for welding exceeds 25% of the diameter/thickness or 25 mm, whichever is smaller. All other weld repairs are considered minor.
- ③ Major weld repairs require approval before the repair is commenced. Procedures are to be qualified according to recognized standards (e.g. ISO 15614 or equivalent) with the following additional requirements: Charpy V notch impact tests with notch locations in weld metal, fusion line and heat affected zone + 2 mm and + 5 mm from fusion line, respectively. Test results are to meet the requirements specified for the parent metal. Proposals for major repairs are to be accompanied by sketches or photographs showing the extent and positions of the repairs.

④ A grain refining heat treatment is to be given to the whole casting prior to major repairs. A post weld heat treatment or repeat of original heat treatment of castings is to be carried out.

⑤ Minor and major weld repairs must be recorded on sketches or photographs showing the extent and positions of the repairs.

10.3.3.4 For the delivery of fForged and cast steels for grades R4S and R5 accessories, ~~are to comply with the following requirements:~~

~~(1) Steel for forgings and castings is to be vacuum degassed.~~

~~(2) In addition to routine steel information, the following information is to be supplied by the mooring accessory manufacturer and the results are to be included in the accessory documentation: non-metallic inclusions, segregation or porosity, jominy hardenability, results of hydrogen embrittlement test and ultrasonic examination as well as welding repair records accompanied by sketches or photographs (if any).~~

10.3.3.5 The studs are to be made of steel corresponding to that of the chain or in compliance with specifications submitted to and approved by CCS ~~and the technical specifications are to be submitted to CCS for approval~~. In general, the carbon content is not to exceed 0.25% or the carbon equivalent is not to exceed 0.58% if the studs are to be welded in place.

10.3.4 Design of mooring chains

10.3.4.1 Drawings accompanied by design calculations, giving detailed design of mooring chain and accessories made by or supplied through the chain manufacturer are to be submitted to CCS for approval. Typical designs of stud link chains are given in Figure 10.2.3.2. For studless chains, the shape and proportions are to comply with the requirements of 10.3.8.6(5). Other studless proportions are to be specially approved. New or non-standard designs of chain links, shackles or accessories may require a fatigue analysis and other possible performance, fatigue or corrosion fatigue testing.

10.3.5 Manufacture of mooring chains

10.3.5.2 Offshore mooring chains are to be manufactured in continuous lengths by flash butt welding and are to be heat treated in a continuous furnace; batch heat treatment is not permitted, except in special circumstances where short lengths of chain are delivered, such as chafing chain ~~and except for chafing chains, heat treated in a continuous furnace; batch heat treatment is not permitted~~. Records of bar heating, flash welding and heat treatment are to be made available for examination by the Surveyor.

10.3.5.4 Bar heating is to comply with the following requirements:

(1) Bars for links are to be heated by electric resistance, induction or in a furnace.

~~(24)~~ For electric resistance heating or induction heating, the heating phase is to be controlled by an optical heat sensor. The controller is to be checked at least once every 8 h and records made.

~~(23)~~ For furnace heating, the heat is to be controlled and the temperature continuously recorded using thermocouples in close proximity to the bars. The controls are to be checked at least once every 8 h and records made.

10.3.5.5 The welding parameters for platen motion, current as a function of time and hydraulic pressure are to be controlled during flash welding of each link. The controls are to be checked at least every 4 h and records made.

10.3.5.6 Heat treatment of mooring chains is to comply with the following requirements:

- (1) Chain is to be austenitized, above the upper transformation temperature, at a combination of temperature and time within the limits established.
- (2) When applicable, chain is to be tempered at a combination of temperature and time within the limits established. Cooling after tempering is to be appropriate to avoid temper embrittlement.
- (3) Temperature and time or temperature and chain speed is to be controlled and continuously recorded.

10.3.5.7 Records of bar heating, flash welding and heat treatment are to be made available for inspection by the Surveyor.

10.3.7 Connecting common links (splice links)

10.3.7.4 Each connecting common link is to be marked either on the stud for stud link chain or, on the outer straight length on the side opposite the flash butt weld for studless chain. This marking is to be in accordance with the requirements of 10.3.10.1 plus a unique number for the link satisfying the requirements of 10.3.10 of this Section. The adjoining links are also to be marked on the studs or straight length as above.

10.3.8 Testing and inspection of mooring chains

10.3.8.1 This section applies to but is not limited to testing and inspection of finished mooring chains such as common stud and studless links, end links, enlarged end links and connecting common links (splice links).

10.3.8.2 Prior to ~~testing and~~ inspection, the chain is to be free from scale, paint or other coating by sand blasting, shot blasting or other suitable means and is to have a suitably prepared surface as per the applied NDE testing standard.

10.3.8.3 Mooring chains are to have a clean surface consistent with the method of manufacture and be free from cracks, notches and other defects impairing the performance of the chain. Each link is to be examined in accordance with approved procedures. The dimensions of mooring chains and accessories are to comply with the relevant standards accepted or special design requirements approved by CCS.

10.3.8.4 All mooring chains are to be subjected to proof load tests, sample break load tests and mechanical tests in accordance with a standard acceptable to CCS after final heat treatment in the presence of the Surveyor. Where the manufacturer has a procedure to record proof loads and the Surveyor is satisfied with the adequacy of the recording system, he need not witness all proof load tests. The Surveyor is, however, to satisfy himself that the testing machines are calibrated and maintained in a satisfactory condition.

10.3.8.5 Mooring chains are to be subject to proof and break tests in accordance with the following requirements:

- (1) The entire length of chain is to withstand the proof load specified in Table 10.3.8.5(1) without

fracture and is not to crack in the flash weld and without obvious stud loosening. The load applied is not to exceed the proof load by more than 10% when stretching the chain. Where plastic straining is used to set studs, the applied load is not to be greater than that qualified in approval tests ~~and is to be recorded in the test report.~~

Proof and Break Test Loads, Weight and Length over 5 Links **Table 10.3.8.5(1)**

Stud link	R3	R3S	R4	R4S	R5
Proof test load (kN)	0.0148 <i>K</i>	0.0180 <i>K</i>	0.0216 <i>K</i>	0.0240 <i>K</i>	0.0251 <i>K</i>
Break test load (kN)	0.0223 <i>K</i>	0.0249 <i>K</i>	0.0274 <i>K</i>	0.0304 <i>K</i>	0.0320 <i>K</i>
Studless	R3	R3S	R4	R4S	R5
Proof test load (kN)	0.0148 <i>K</i>	0.0174 <i>K</i>	0.0192 <i>K</i>	0.0213 <i>K</i>	0.0223 <i>K</i>
Break test load (kN)	0.0223 <i>K</i>	0.0249 <i>K</i>	0.0274 <i>K</i>	0.0304 <i>K</i>	0.0320 <i>K</i>
Chain weight (kg/m)	Stud link = 0.0219 <i>d</i> ²		Studless chain Weight calculated for each design		
Length <i>L</i> over 5 links	22 <i>d</i> ≤ <i>L</i> ≤ 22.55 <i>d</i>				

where: $k = d^2 (44-0.08d)$;

d —nominal chain diameter, in mm.

(2) A break test specimen consisting of at least 3 links is to be either taken from the chain or produced at the same time and in the same manner as the chain. The test frequency is to be based on tests at sampling intervals according to Table 10.3.8.5(2) provided that every cast is represented. Each specimen is to be capable of withstanding the break load specified in Table 10.3.8.5(1) without fracture and is not to crack in the flash weld. It will be considered acceptable if the specimen is loaded to the specified value and maintained at that load for 30 s.

Sampling Frequency of Break and Mechanical Tests **Table 10.3.8.5(2)**

Nominal chain diameter (mm)	≤ 48	49~60	61~73	74~85	86~98	99~111	112~124	125~137
Maximum sampling interval (m)	91	110	131	152	175	198	222	250
Nominal chain diameter (mm)	138~149	150~162	163~175	176~186	187~199	200~210	<u>211~222</u>	
Maximum sampling interval (m)	274	297	322	346	<u>370</u> ~~370~~	395	<u>420</u>	

(3) For chain diameters over 100 mm, alternative break-test proposals to the above break test will be considered whereby a one link specimen is used. Alternatives are to be approved by CCS, every heat is to be represented, the test frequency is to be in accordance with Table 10.3.8.5(2), and it is to be demonstrated and proven that the alternative test represents an equivalent load application to the three link test.

(4) If the loading capacity of the testing machine is insufficient, ~~another equivalent method is to be~~ an alternative load testing machine is to be used that does have sufficient capacity (e.g. two loading machines in parallel) provided the testing and calibration procedure are agreed with CCS.

10.3.8.6 After proof load testing, measurements are to be taken on at least 5 per cent of the links in accordance with the following requirements. The shape and proportions of links are to comply

with recognized standards or specially approved design requirements as well as the following tolerance requirements:

(1) The maximum and minimum dimensions measured at the crown are to comply with the tolerance requirements in Table 10.3.8.6(1). However, the cross-sectional area at the crown must have no negative tolerance. The cross sectional area at the crown is to be calculated using the average of the diameters with negative tolerance and plus tolerance, measurements are to be taken from at least 2 locations approximately 90 degrees apart.

Allowable Tolerance of Diameter at Crown **Table 10.3.8.6(1)**

Nominal chain diameter d (mm)	≤ 40	$40 < d \leq 84$	$84 < d \leq 122$	$122 < d \leq 152$	$152 < d \leq 184$	$184 < d \leq 222$	$222 < d$
Negative tolerance (mm)	1	2	3	4	6	7.5	
Plus tolerance (mm)	<u>For diameters of 20 mm or greater: $0.05d$</u> <u>For diameters less than 20 mm: to be agreed with CCS at the time of approval</u>						

(2) Diameter measured at locations other than the crown is to have no negative tolerance. The plus tolerance may be up to 5% of the nominal diameter. The plus tolerance of the diameter at the flash-butt weld is to comply with the manufacturer's specifications approved by CCS. For diameters less than 20 mm, the plus tolerance is to be agreed with CCS at the time of approval.

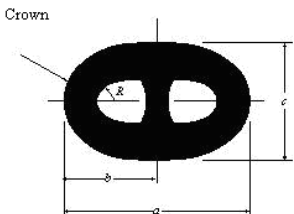
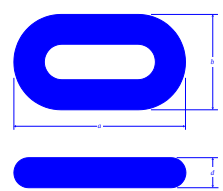
(3) The allowable manufacturing tolerance on a length of 5 links is to be 0% to +2.5% (measured with the chain loaded up to 10% of the minimum proof load).

(4) Except as required by Table 10.3.8.6(5), all other dimensions are to be subject to a manufacturing tolerance of 2.5%, provided that all of the final link parts of the chain fit together properly.

(5) The tolerance of stud link and studless common links is to comply with the relevant requirements of Table 10.3.8.6(5). The internal and external radii of the link are to be uniform.

(6) For stud links, studs are to be located in the links centrally and at right angles to the sides of the link. The following tolerances in Table 10.3.8.6(5) are acceptable provided that the stud fits snugly and its ends lie practically flush against the inside of the link. In general the stud is to penetrate the link for 2-6% of the diameter of link.

Dimensions and Tolerances of Common Links **Table 10.3.8.6(5)**

							
Designation	Description	Nominal dimension of stud link	Minus tolerance	Plus tolerance	Nominal dimension of studless link	Minus tolerance	Plus tolerance
A	Link length	$6d$	$0.15d$	$0.15d$	$6d$	$0.15d$	$0.15d$
B	Link half length	$a^*/2$	$0.1d$	$0.1d$	Not applicable	—	—
C	Link width	$3.6d$	$0.09d$	$0.09d$	$3.35d$	$0.09d$	$0.09d$
E	Stud angular misalignment	0°	4°	4°	Not applicable	—	—
R	Inner radius	$0.65d$	0	—	$0.60d$	0	—

Notes: ① d = Nominal diameter of chain, a^* = Actual link length.

② Other dimension ratios of studless links are subject to special approval by CCS.

10.3.8.7 After proof testing, the entire g chain is to be checked for the length, five links at a time. By the check the first five links are to be measured. From the next set of five links, at least two links from the previous five links set are to be included. This procedure is to be followed for the entire chain length. The measurements are to be taken preferably while the chain is loaded to ~~5%~~ $\pm 10\%$ of the minimum proof load. The tolerances for the 5 link measurements are indicated in Table 10.3.8.5(1), any deviations from the 5 link tolerances are to be agreed by the client and CCS. The links held in the end blocks may be excluded from this measurement.

10.3.8.8 According to the test frequency and sampling requirements in Table 10.3.8.5(2), links of samples detached from finished, heat treated chain are to be sectioned for metallurgical examination and determination of mechanical properties as follows:

(1) A metallographic sample (one from each ladle in case the heat number of material can be confirmed) is to be taken to examine the austenitic grain size according to a recognized standard (e.g. ISO 643) at 1/3 radius and centre from surface for the base material, HAZ and weld. The austenitic grain size is to be 6 or finer.

(24) A test unit is to consist of one tensile specimen and three sets of three Charpy V-notch impact test specimens. The sampling locations are as shown in Figure 10.3.8.8(42) or Figure 3.12.5.2, Section 12, Chapter 3 of this PART and comply with the following requirements:

the tensile specimen is to be taken in the side opposite the flash weld;

the first set of three impact specimens is to be taken across the flash weld with the notch centered in the middle;

the second set of three impact specimens is to be taken across the unwelded side;

the third set of three impact specimens is to be taken from the bend region.

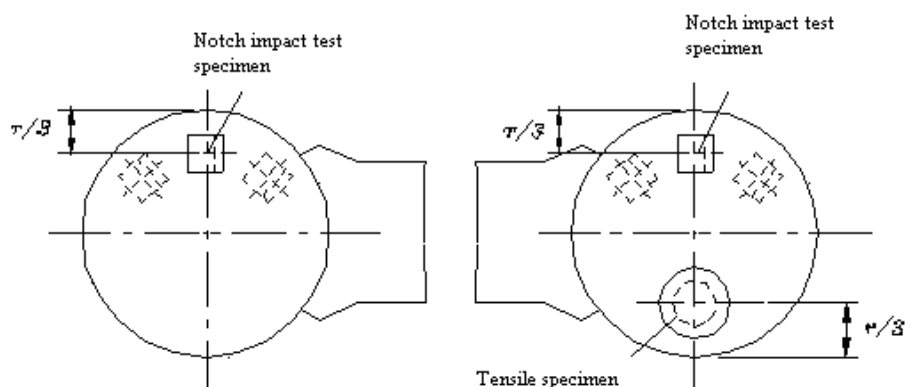


Figure 10.3.8.8(42)

(23) The frequency of impact testing in the bend may be reduced at the discretion of CCS provided it is verified by statistical means that the required toughness is consistently achieved.

(34) The test results are to comply with the requirements of Table 10.3.8.8(34).

Mechanical Properties of Mooring Chains and Accessories

Table 10.3.8.8(34)

Grade	Yield point $R_{p0.2}$ (N/mm ²)	Tensile strength R_m (N/mm ²)	Elongation A_5 (%)	Reduction of area Z (%)	Charpy V-notch impact test		
					Test temperature (°C)	Impact energy (J)	
						Base metal	Weld metal
R3	≥ 410	≥ 690 ^②	≥ 17	50	0(-20) ^①	≥ 60(40)	≥ 50(30)
R3S	≥ 490	≥ 770 ^②	≥ 15	50	0(-20) ^①	≥ 65(45)	≥ 53(33)
R4	≥ 580	≥ 860 ^②	≥ 12	50	-20	≥ 50	≥ 36
R4S ^③	≥ 700	≥ 960 ^②	≥ 12	50	-20	≥ 56	≥ 40
R5 ^③	≥ 760	≥ 1000 ^②	≥ 12	50	-20	≥ 58	≥ 42

Notes: ① In general, the temperature of impact test for Grades R3 and R3S chains is 0 °C. Where it is required by the purchaser, -20 °C may be regarded as a supply condition.

② The yield to tensile ratio is generally not to be greater than 0.92.

③ Maximum hardness for R4S is to be 330 HBW and R5 340 HBW.

10.3.8.9 Hardness tests are to be carried out on finished chain. The frequency and locations are to be agreed with CCS. The recorded values are for information only and used as an additional check to verify that the heat treatment process has been stable during the chain production.

10.3.8.10 After proof testing, chain is to be positioned in order to have good access to all surfaces and all surfaces of every link are to be visually examined. In order to allow optimal access to the surface area it is recommended that chain be hung in the vertical position, however access to inspect the interlink area may only be possible with the chain in the horizontal position. Burrs, irregularities and rough edges are to be contour ground. Links are to be free from mill defects, surface cracks, dents and cuts, especially in the vicinity where gripped by clamping dies during flash welding. Studs are to be securely fastened and free from loosening.

10.3.8.11 Magnetic particles are to be employed to examine the following positions in accordance with the following requirements and using the same equipment, procedures and equipment in accordance with those approved acceptance criteria submitted to CCS at the time of approval:

(1) flash welded area including the area gripped by the clamping dies; additionally,

(2) all accessible surfaces of 10% of links;

(3) testing is to be performed in accordance with a recognized standard (e.g. ISO 9934) using wet continuous fluorescent magnetization technique. Non fluorescent techniques can be accepted in special cases where the standard inspection procedures are impractical;

(4) link surfaces and the surface at the flash weld are to be free from cracks, lack of fusion and gross porosity. Links are to be free from relevant linear indications exceeding 1.6 mm in transverse direction, relevant linear indications exceeding 3.2 mm in longitudinal direction or relevant non-linear indications exceeding 4.8 mm.

10.3.8.12 Ultrasonics are to be employed to examine the mooring chain in accordance with the

following requirements and using the same equipment, procedures and acceptance criteria submitted to CCS at the time of approval:

(1) On-site calibration standards for chain configurations are to be approved by CCS.

(2) Ultrasonics are to be employed to examine the flash weld fusion of every link.

(3) The flash butt welds are to be ultrasonic tested (UT) in accordance with a recognized standard (e.g. ASTM E587) using single probe, angle-beam shear waves in the range from 45 to 70 °. Single probe technique has limitations as far as testing of the central region is concerned and the flash weld imperfections such as flat spots may have poor reflectivity. Where it is deemed necessary, detectability of imperfections may need to be carried out by using a tandem technique, TOFD or phased array.

(4) The flash weld is to be free from defects causing ultrasonic back reflections equal to or greater than the calibration standard.

10.3.8.13 Stud welds, if used, are to be visually inspected. The toes of the fillets are to have a smooth transition to the link with no undercuts exceeding 1.0 mm. Additionally, at least 10% of the stud welds distributed through the length are to be dye penetrant or magnetic particle tested according to a recognized standard (e.g. ASTM E1417 or ASTM E1444). Cracks, lack of fusion or gross porosity are not acceptable. If defects are found, testing is to be extended to all stud welds in that length.

10.3.9 Retest, rejection and repair criteria

10.3.9.1 If the length over 5 links is short, the chain may be stretched by loading above the proof test load specified provided that the applied load is not greater than that approved and that only random lengths of the chain need stretching. The stretched links are to be recorded in the report. If the length exceeds the specified tolerance, the over length chain links are to be cut out and 10.3.9.2 is to apply.

10.3.9.2 If single links are found to be defective or to not meet other applicable requirements, defective links may be cut out and a connecting common link inserted in their place. The individual heat treatment and inspection procedure of connecting common links is subject to approval by CCS. Other methods for repair are subject to the written approval of CCS and the end purchaser. Weld repair of chain is not permitted.

10.3.9.3 If a crack, cut or defect in the flash weld is found by visual or magnetic particle examination, it is to be ground down no more than 5% of the link diameter in depth and streamlined to provide no sharp contours. The final dimensions must still conform to the agreed standard.

10.3.9.5 If link diameter, length, width and stud alignment do not conform to the required dimensions, these are to be compared to the dimensions of 40 more links; 20 on each side of the affected link. If a single particular dimension fails to meet the required dimensional tolerance in more than 2 of the sample links, all links are to be examined. Defective links are to be cut out and replaced in accordance with the requirements of 10.3.9.2.

10.3.9.7 If a link fails during proof load testing, a thorough examination with the Surveyor

informed in a timely manner is to be carried out to identify the probable cause of failure of the proof test. ~~In addition to the above failure investigation, a break test specimen is to be taken from each side of the one failed link, and subjected to the break test. Based upon satisfactory results of both break tests and the results of the failure investigation, it will be decided what length of chain can be considered for acceptance. Failure of either break test will result in rejection of the same proof loaded length.~~ In the event that two or more links in the proof loaded length fail, that length is to be rejected. The above failure investigation is to be carried out especially with regard to the presence in other lengths of factors or conditions thought to be causal to failure.

10.3.9.8 In addition to the above failure investigation, a break test specimen is to be taken from each side of the one failed link, and subjected to the break test.

Where multiple chains are produced simultaneously it is recognised that the preceding flash butt welded link and subsequent flash butt welded link will be on an alternative chain length or the other end of the chain length. In such cases CCS may require that two additional break tests are to be taken from the lengths of chain that include the preceding and subsequent welded links. Based upon satisfactory results of both break tests and the results of the failure investigation, it will be decided what length of chain can be considered for acceptance. Failure of either or both breaking tests will result in rejection of the same proof loaded length. Replacement of defective links is to be in accordance with 10.3.7.

If the investigation identifies defects in the flash butt weld or a lower strength flash weld “a glue-weld” is found, additional NDT such as phased array UT is to be carried out to identify if other links are affected. A full assessment of the flash butt welding machine is to be carried out, together with assessment of the condition of the bar ends prior to welding.

10.3.9.9~~8~~ Re-test requirements for tensile and impact tests are to be in accordance with the relevant requirements of Section 2, Chapter 1 of this PART. Failure to meet the specified requirements of either or both additional tests will result in rejection of the sampling length of chain represented.

10.3.10 Marking, certification and documentation

10.3.10.1 The chain which has been satisfactorily inspected by CCS is to be marked at the following places:

- (1) at each end;
- (2) at intervals not exceeding 100 m;
- (3) on connecting common links;
- (4) on links next to shackles or connecting common links.

10.3.10.2 All marked links are to be stated on the certificate, and the marking is to make it possible to recognize the leading and tail end of the chain. In addition to the above required marking, the first and last common link of each individual charge used in the continuous length is to be adequately and traceably marked. The marking is to be permanent and legible throughout the expected lifetime of the chain.

10.3.10.32 The chain is to be marked on the studs as follows:

- (1) chain grade;
- (2) certificate number;
- (3) CCS stamp.

10.3.10.4 The certificate number may be exchanged against an abbreviation or equivalent. If so, this is to be stated in the certificate.

10.3.10.53 The chain certificate is to contain information on number and location of connecting common links. The certificate number and replacement link number may be exchanged against an abbreviation or equivalent. If so, this is to be stated in the certificate.

10.3.10.64 A complete Chain Inspection and Testing Report in booklet form is to be provided by the chain manufacturer for each continuous chain length. This booklet is to include all dimensional checks, test and inspection reports, NDT reports, process records, photographs as well as any non-conformity, corrective action and repair work. In addition, certificates for materials, the location and number of replacement links are to be included.

Individual certificates are to be issued for each continuous single length of chain. All accompanying documents, appendices and reports are to carry reference to the original certificate number.

The manufacturer will be responsible for storing, in a safe and retrievable manner, all documentation produced for a period of at least 10 years.

10.3.11 Testing and inspection of accessories

10.3.11.1 This section applies to but is not limited to testing and inspection of finished accessories such as detachable connecting links (~~Kenter~~ shackles), detachable connecting plates (triplates), end shackles, swivels and swivel shackles.

10.3.11.2 All accessories are to be subjected to proof load tests, sample break load tests and sample mechanical tests after final heat treatment in the presence of a Surveyor. Where the manufacturer has a procedure to record proof loads and the Surveyor is satisfied with the adequacy of the recording system, he need not witness all proof load tests. The Surveyor is to satisfy himself that the testing machines are calibrated and maintained in a satisfactory condition. Prior to testing and inspection the chain accessories are to be free from scale, paint or other coating.

10.3.11.3 For accessory production a Manufacturing Procedure Specification (MPS) is to be submitted to CCS that details all critical aspects of accessory production, casting, forging, heat treating (including arrangement and spacing of components in the heat treatment furnaces), quenching, mechanical testing, proof and break loading and NDE.

10.3.11.34 All accessories are to be subjected to the proof load specified for the corresponding stud link chain.

10.3.11.45 At least one accessory out of every batch or every 25 accessories, whichever is less, is to be tested to the break load prescribed for the grade and size of chain for which they are

intended. A batch is defined as accessories that originate from the same heat treatment charge and the same heat of steel.

For individually produced, individually heat treated, accessories or accessories produced in small batches (less than 5), alternative equivalent testing is to be approved by CCS and the following additional conditions may apply.

(a) Alternative testing is described in a written procedure and manufacturing procedure specification (MPS).

(b) A finite element analysis is provided at the break load and demonstrates that the accessory has a safety margin over and above the break load of the chain.

(c) Strain age testing (as per approved procedure by CCS) is carried out on the material grade produced to the same parameters at the time of qualification.

(d) If an accessory is of a large size that will make heat treating in batches unfeasible or has a unique design, strain gauges are to be applied during the proof and break load tests during initial qualification and during production. The strain gauge results from production are to be comparable with the results from qualification.

The accessories which have been subjected to the break load test are to be destroyed and not used as part of an outfit.

10.3.11.56 At least one accessory (of the same type, size and nominal strength) out of 25 is to be checked for dimensions after proof load testing. The manufacturer is to provide a statement indicating compliance with the purchaser's requirements.

10.3.11.67 The following tolerances are applicable to accessories:

nominal diameter: 0% to +5%;

other dimensions: $\pm 2.5\%$.

These tolerances do not apply to machined surfaces.

10.3.11.78 Mechanical tests are to be taken from proof loaded full size accessories that have been heat treated with the production accessories they represent. At least one accessory out of every batch or every 25 accessories, whichever is less, is to be tested. Hardness tests are to be carried out on finished accessories. The frequency and locations are to be agreed with CCS. The recorded values are for information only and used as an additional check to verify that the heat treatment process has been stable during the accessory production.

The use of separate representative coupons is not permitted except for accessories with complex geometries.

10.3.11.89 Mechanical tests of accessories are to satisfy the following requirements:

(1) Forged shackle bodies and forged Kenter shackles are to have a set of three impact test specimens and a tensile test specimen taken from the crown of the shackle as shown in Figure 10.3.8.8(±2), with the impact specimens on the outside radius. Tensile test specimens on smaller diameter shackles can be taken from the straight part of the shackle, where the geometry does not

permit a tensile specimen from the crown. The tensile properties and impact values are to meet the requirements of Table 10.3.8.8(34). ~~The sampling locations of other accessories with complex geometries are to be agreed with CCS.~~

~~10.3.11.9(2)~~ The locations of mechanical tests of cast shackles and cast Kenter shackles can be taken from the straight part of the accessory. The tensile properties and impact values are to meet the requirements of Table 10.3.8.8(34) in the locations specified in Figure 10.3.8.8(42).

(3) The locations of mechanical tests of other accessories with complex geometries are to be agreed with CCS. For non-circular sections, 1/4t (thickness) from the surface is considered appropriate. Rolled plates are to be tested to the Standard to which they are produced.

10.3.11.10 For individually produced (heat treated) accessories or accessories produced in small batches (less than 5), alternative testing can be proposed. Each proposal for alternative testing is to be detailed by the manufacturer in a written procedure and submitted to CCS for approval, and the following additional conditions may apply:

(1) If separately forged or cast coupons are used, they are to have a cross-section and, for forged coupon, a reduction ratio similar to that of the accessories represented, and are to be heat treated in the same furnace and quenched in the same tank at the same time, as the actual forgings or castings. Thermocouples are to be attached to the coupon and to the accessories.

(2) If separately forged or cast coupons are agreed, it is to be verified by procedure test that coupon properties are representative of accessory properties.

10.3.11.11 Mechanical tests of pins are to be taken as per right part of Figure 10.3.8.8(42) from the mid length of a sacrificial pin of the same diameter as the final pin. For oval pins, the diameter taken is to represent the smaller dimension. Mechanical tests may be taken from an extended pin of the same diameter as the final pin that incorporates a test prolongation and a heat treatment buffer prolongation, where equivalence with mid length test values have been established. The length of the buffer is to be at least equal to 1 pin diameter dimension which is removed after the heat treatment cycle is finished. The test coupon can then be removed from the pin. The buffer and test are to come from the same end of the pin as per Figure 10.3.11.11.

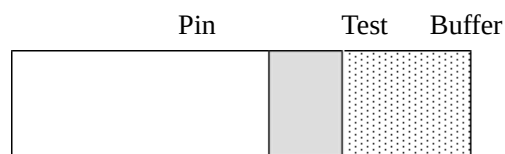


Figure 10.3.11.11 Buffer and test piece location

10.3.11.12 After proof load testing, non-destructive examination is to be carried out according to the following requirements:

(1) All chain accessories are to be subjected to a close visual examination. Special attention is to be paid to machined surfaces and high stress regions. Prior to inspection, chain accessories are to have a suitably prepared surface as per the applied NDE testing standard. All non-machined surfaces are to be sand or shot blasted to permit a thorough examination. Where applicable,

accessories are to be dismantled for inspection of internal surfaces. All accessories are to be checked by magnetic particles or dye penetrant. UT of accessories may be required by CCS.

(2) Non-destructive examination is to be carried out according to approved standards ~~and procedures~~ (such as those indicated in Table 10.3.11.11). Testing procedures and relevant acceptance criteria are to be submitted to CCS for review.

Applicable NDE Standards of Mooring Chain Accessories **Table 10.3.11.11**

<u>Accessory materials</u>	<u>Testing method</u>	<u>Applicable standards</u>
<u>Forgings</u>	<u>Magnetic particle testing</u>	<u>ISO 4986, IACS Rec.69, EN 10228-1, ASTM A275</u>
	<u>Ultrasonic testing</u>	<u>ISO 13588, EN 10228-3, ASTM A388</u>
<u>Castings</u>	<u>Magnetic particle testing</u>	<u>ASTM E709, wet continuous magnetization technique</u>
	<u>Ultrasonic testing</u>	<u>ISO 13588, ASTM A609</u>

(3) All surfaces are to be magnetic particle tested (MT). Testing is to be performed in accordance with standards referenced using the fluorescent technique. As a minimum surfaces are to be free from:

relevant linear indications exceeding 1.6 mm in transverse direction;

relevant linear indications exceeding 3.2 mm in longitudinal direction;

relevant non-linear indications exceeding 4.8 mm.

(4) When required by CCS, ultrasonic testing is to be carried out on 100% of cast or forged accessories. The acceptance/rejection criteria established for the design is to be met.

(5) The manufacturer is to provide a statement that non-destructive examination has been carried out with satisfactory results. This statement is to include a brief reference to the techniques and to the operator's qualification.

10.3.11.13 Weld repairs of finished accessories are not permitted.

10.3.11.134 In the event of a failure of any test, the entire batch represented is to be rejected unless the cause of failure has been determined and it can be demonstrated to the Surveyor's satisfaction that the condition causing the failure is not present in any of the remaining accessories.

10.3.12 Marking, certification and documentation of accessories

10.3.12.3 A complete Inspection and Testing Report in booklet form is to be provided by the manufacturer for each order. This booklet is to include all dimensional checks, test and inspection reports, NDT reports, process records and example photographs of components positioned in furnaces, as well as any nonconformity, corrective action and repair work.

10.3.12.4 Each type of accessory is to be covered by separate certificates. All accompanying documents, appendices and reports are to carry reference to the original certificate number. ~~The manufacturer will be responsible for storing, in a safe and retrievable manner, all documentation produced for a period of at least 10 years.~~

10.3.12.5 The manufacturer will be responsible for storing, in a safe and retrievable manner, all documentation produced for a period of at least 10 years.

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:

2.2.6.4 If PVC and SAN (Styrene acrylonitrile copolymer) foams are used as the core materials of sandwich panel, their density is not to be less than 60 kg/m³, and their basic mechanical properties at ambient temperature are not to be less than those as required in Table 2.2.6.4. For other foams, this table may be used as a reference. For items not mentioned in the table, the results are to comply with limit values specified in the standards or by the manufacturer.

2.2.6.8 Balsa is to be tested for the following items, the results of which are to comply with the requirements of Table 2.2.6.8. For items not mentioned in the table, the results are to comply with limit values specified in the standards or by the manufacturer:

2.2.7.7 The working conditions of epoxy resin chocks intended for approval are a static load usually not greater than 0.7 N/mm² caused by equipment weight, maximum static load (equipment weight plus bolt fastening force) not greater than 4.5 N/mm² on chocks and temperature not greater than 80°C. The requirements for properties of the castings are given in Table 2.2.7.7. For items not mentioned in the table, the results are to comply with limit values specified in the standards or by the manufacturer.

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. ~~The properties in 2.2.8.4 other than those mentioned in the Table are to be within the range specified by the manufacturer.~~ For items not mentioned in the table, the results are to comply with limit values specified in the standards or by the manufacturer.

CHAPTER 3 FIBER-REINFORCED PLASTIC HULL MATERIALS

Section 1 GENERAL PROVISIONS

3.1.3.3(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 content of the specimen are also to be measured.

A new Section 5 is added as follows:

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

3.5.1 General requirements

3.5.1.1 Where direct calculations are required for fiber-reinforced plastic craft, the submitted data of material properties are to satisfy the requirements of this Section.

3.5.1.2 All submitted data of material properties are to be furnished with corresponding testing report. For finished products such as core materials, the technical data sheet may be accepted. For Poisson ratio, the data in the literature may be accepted.

3.5.1.3 For direct calculations of fiber-reinforced plastic craft, the overall mechanical properties of structural members may be calculated or laminated calculation of material properties given by laminated methods of structural members.

3.5.2 Definitions and terms

3.5.2.1 One ply material means the material combined by 1 layer of reinforced material (mat or cloth) and resin.

3.5.2.2 Fiber-reinforced plastic laminated plate means a fiber-reinforced plastic plate consisting of multiple one ply material.

3.5.2.3 Direction 1 means the in-plane direction of fiber main bearing strength.

3.5.2.4 Direction 2 means the in-plane direction vertical to fiber main bearing strength direction.

3.5.2.5 Direction 3 means the direction vertical to directions 1 and 2.

3.5.3 Material properties required for the overall calculation of structural members

3.5.3.1 For fiber-reinforced plastic laminated plates, the tensile modulus (E_t), compressive modulus (E_c) and shear modulus (G) along directions 1 and 2 and Poisson ratio are to be submitted.

3.5.3.2 For sandwich structural materials, the overall mechanical performance properties may be submitted; or the material properties of fiber-reinforced plastic laminated plates and core materials may be submitted in accordance with the provisions of 3.5.3.1. For non-isotropic core materials, the data along direction 3 is also to be submitted.

3.5.4 Material properties required for laminated calculation

3.5.4.1 The tensile modulus (E_t), compressive modulus (E_c) and shear modulus (G) of one ply materials along directions 1 and 2 and Poisson ratio are to be submitted.

3.5.4.2 For core materials of sandwich structures, the data specified in 3.5.4.1 is to be submitted. For non-isotropic core materials, the data along direction 3 is also to be submitted.

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

Properties of One ply Materials

Table 3.5.4.3

Item	Testing method
Tensile strength and modulus	ISO 527-4, ISO 527-5
Compressive strength	ISO 14126
Shear strength and modulus	ISO 14130

3.5.4.4 Where the stress criteria are used for direct calculation, in addition to the material properties required by 3.5.3.1 or 3.5.4.1, the tensile strength, compressive strength and shear strength of overall structural members or one ply materials are also to be submitted.”

PART THREE WELDING

CHAPTER 2 WELDING CONSUMABLES

Section 3 ELECTRODES FOR MANUAL ARC WELDING

2.3.6 Hydrogen test

2.3.6.1 The diffusible hydrogen test is to adopt mercury method or thermal conductivity detector method specified in ISO 3690-2012. Four weld assemblies are to be prepared. For heat conductivity detector method, the minimum holding time at different test temperature is to comply with the provisions of Table 2.3.6.1. For welding consumables with level of hydrogen content of H10 and H15, glycerin method specified in 2.3.6.2 may also be adopted.

New Table 2.3.6.1 is added as follows:

**Relationship between Test Temperature and Minimum Holding Time
where Thermal Conductivity Detector Method is Used** **Table 2.3.6.1**

Measuring Method		Test Temperature (°C)	Minimum Holding Time (h)
Thermal Conductivity Detector Method ^①	Gas Chromatography (hydrogen collection method)	45	72
		150	6

① Thermal conductivity detector method includes gas chromatography method ((hydrogen collection method)) and hot carrier gas extraction method. The use of hot carrier gas extraction method may be considered subject to verification of the testing procedure to confirm that collection and measurement of the hydrogen occurs continuously until all of the diffusible hydrogen is quantified.

2.3.6.2 The procedure for hydrogen test with glycerin method is as follows:

- (1) Four plates of any grade of hull structural steel are to be prepared as hydrogen test specimens. The specimens are to be 12 mm in thickness, 25 mm in width and 125 mm in length.
- (2) Before welding, the specimens are to be cleaned and weighed to the nearest 0.1 g.
- (3) Prior to welding, the electrodes are to be baked according to the drying process recommended by the manufacturer, so as to fully dry the electrodes. On the 25 mm surface of each test specimen, a single bead of welding about 100 mm in length is to be deposited with a 4 mm electrode, using about 150 mm of the electrode. The welding is to be carried out with as short an arc as possible and with a current of about 150 A.
- (4) Within 30 s of the completion of the welding of each specimen, the slag is to be removed and the specimen quenched in water having a temperature of approximately 20°C. After a further 30 s, the specimens are to be cleaned and placed in an apparatus suitable for the collection of hydrogen by displacement of glycerin. All four specimens are to be welded and placed in the hydrogen collecting apparatus within 30 min by a single operator.
- (5) The specimens are to be kept immersed in the glycerin having a temperature of 45°C for a period of 48 h and, after removal, are to be cleaned in water and spirit, dried and weighed to the nearest 0.1 g to determine the amount of weld deposited.

The amount of gas evolved is to be measured to the nearest 0.05 cm³ and corrected for temperature and pressure to 0°C and 101.325 kPa.

2.3.6.3 The individual and average diffusible hydrogen contents of the four specimens are to be reported, and the average value of diffusible hydrogen per 100 g is not to exceed ~~to comply with~~ the values in ~~requirements of~~ Table 2.3.6.3.

Table 2.3.6.3 is replaced by the following:

Average value of diffusible hydrogen

Table 2.3.6.3

Mark	Diffusible Hydrogen Contents	Measuring Method
H15	15cm ³ ①	Mercury Method Thermal Conductivity Detector Method Glycerin Method ③
H10	10cm ³ ②	
H5	5cm ³	Mercury Method Thermal Conductivity Detector Method

Notes: ① 10 cm³ per 100 grams where the glycerin method is used.

② 5 cm³ per 100 grams where the glycerin method is used.

③ The glycerin method is not to be used for the welding consumables with H 5 mark.

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

2.5.1 General requirements

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

Composition of the Shielding Gas

Table 2.5.1.3

**Compositional Limits of Designated Groups
of Gas Types and Mixtures**

Group	Gas composition (Vol. %)			
	Argon (Ar)	Carbon dioxide (CO ₂)	Oxygen (O ₂)	Hydrogen (H ₂)
M11	Residual ^{①②}	0 ~ 5	—	0 ~ 5
M12	Residual ^{①②}	0 ~ 5	—	—
M13	Residual ^{①②}	—	0 ~ 3	—
M14	Residual ^{①②}	0 ~ 5	0 ~ 3	—
M21	Residual ^{①②}	5 ~ 25	—	—
M22	Residual ^{①②}	—	3 ~ 10	—
M23	Residual ^{①②}	5 ~ 25	0 ~ 8	—
M31	Residual ^{①②}	25 ~ 50	—	—
M32	Residual ^{①②}	—	10 ~ 15	—
M33	Residual ^{①②}	5 ~ 50	8 ~ 15	—

C1	—	100	—	—
C2	—	Residual	0 ~ 30	—

Notes: ① 95% of the content of argon gas may be substituted by helium gas.

② The content of helium gas used is to be greater than or equal to that of argon gas.

Section 9 WELDING CONSUMABLES FOR ALUMINUM ALLOYS

2.9.2 General requirements

2.9.2.4 Approval of a wire or a rod will be granted in conjunction with a specific shielding gas according to Table 2.9.2.4 or defined in terms of composition and purity of “special” gas to be designated with group sign “S”. The composition of the shielding gas is to be reported. The approval of a wire or rod with any particular gas can be applied or transferred to any combination of the same wire or rod and any gas in the same numbered group as defined in Table 2.9.2.4, subject to agreement of CCS.

**Compositional Limits of Groups and Compositions of
Shielding Gases and Mixtures to be Used**

Table 2.9.2.4

Group	Gas composition (Vol. %)	
	Argon	Helium
I-1	100	—
I-2	—	100
I-3	Remainder	$0 < \text{He} \leq 33$
I-4	Remainder	$33 < \text{He} \leq 66$
I-5	Remainder	$66 < \text{He} \leq 95$
S	Gases of other chemical composition (mixed gases) may be considered as “special gases” and covered by a separate test	

CHAPTER 3 APPROVAL OF WELDING PROCEDURES

Section 2 WELDING PROCEDURE APPROVAL TESTS FOR BUTT WELDS

3.2.5 Welding procedure test results for steel structures

3.2.5.4 The temperature for Charpy V-notch impact tests is to comply with Table 3.2.5.4(a) and the test results are to comply with Table 3.2.5.4(b).

Temperature for Impact Test				Table 3.2.5.4(a)	
Grade of steel	A, AH32, AH36, AH40	B, D, DH32, DH36, DH40, AH420, AH460, AH500, AH550, AH620, AH690, AH890, AH960	E, EH32, EH36, EH40, EH420, EH460, EH500, EH550, EH620, EH690, EH890, EH960	FH32, FH36, FH40, FH420, FH460, FH500, FH550, FH620, FH690	FH420, FH460, FH500, FH550, FH620, FH690
Test temperature (°C)	20	0	-20	-40	-60

Ductility for Impact Test ^①											Table 3.2.5.4(b)	
Grade of steel	A, B ^② , D, E	AH32, DH32, EH32, FH32	AH36, DH36, EH36, FH36	AH40, DH40, EH40, FH40	AH420, DH420, EH420, FH420	AH460, DH460, EH460, FH460	AH500, DH500, EH500, FH500	AH550, DH550, EH550, FH550	AH620, DH620, EH620, FH620	AH690, DH690, EH690, FH690	AH890, DH890, EH890	AH960, DH960, EH960
Average energy (J)	47 ^③		47 ^④	28	31	33	37	41	46			

Notes: ① For thicknesses above 50 mm, impact test requirements are to be agreed by CCS.

② For Grades A and B steels, average absorbed energy on fusion line and in heat affected zone is to be minimum 27 J.

③ The average energy may be 34 J for vertical welding of manually or semi-automatically welded joints and for automatic welding. For manually or semi-automatically welded joints, the average energy is to be 47 J for downhand welding, horizontal welding and overhead welding.

④ The average energy may be 39 J for vertical welding of manually or semi-automatically welded joints and for automatic welding. For manually or semi-automatically welded joints, the average energy is to be 47 J for downhand welding, horizontal welding and overhead welding.

⑤ Except for hull structural steels listed in the Table, the impact test temperature and impact energy for welded joints of normal strength steel are to comply with the requirements for parent material.

3.2.5.6 The results from the hardness test are given in Table 3.2.5.6. ~~not to exceed the following:~~

~~— steel with a specified minimum yield strength $R_{eH} \leq 420 \text{ N/mm}^2$; HV350;~~

~~— steel with a specified minimum yield strength $420 \text{ N/mm}^2 < R_{eH} \leq 690 \text{ N/mm}^2$;~~

~~HV420.~~

A new Table 3.2.5.6 is added as follow:

Requirements for Hardness Test Results of Weld Joints

Table 3.2.5.6

Steel with a specified minimum yield strength R_{eH} (N/mm ²)	Allowable maximum hardness value of welded joints
$R_{eH} \leq 420$	HV350
$420 < R_{eH} \leq 690$	HV420
$690 < R_{eH} \leq 960$	HV450

3.3.3.2 For fillet welds in plates, the specimens are to be taken as shown in Figure 3.3.3.2. Both ends of the test assembly are to be discarded for a length about 50 mm, then two macrosections about 25 mm in length are to be taken, one at the mid-length of the test assembly and the other at stop/restart points. For steels with specified minimum yield strength not less than 355 N/mm²(including duplex stainless steel), the specimen with stop/restart points is also used for hardness test. Fracture tests are to be carried out on the longer part of the remainder of the test assembly.

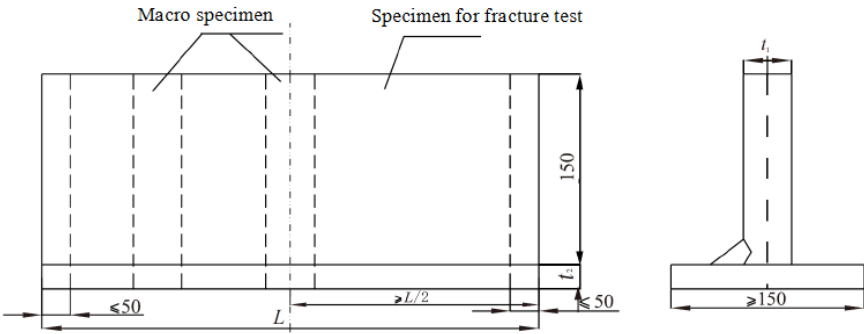


Figure 3.3.3.2

Section 3 WELDING PROCEDURE APPROVAL TESTS FOR FILLET WELDS

3.3.4 Test results

3.3.4.3 The results from the hardness test of steel structures are given in Table 3.2.5.6, Section 2 of this Chapter, not to exceed the following:

- ~~steel with a specified minimum yield strength $R_{eH} \leq 420$ N/mm²: HV350;~~
- ~~steel with a specified minimum yield strength 420 N/mm² $< R_{eH} \leq 690$ N/mm²: HV420.~~

Section 4 FULL-PENETRATION WELDING PROCEDURE APPROVAL TESTS FOR INCLINED OR T-SHAPED TUBULAR JOINTS

3.4.4 Test results

3.4.4.3 The results from the hardness test are given in Table 3.2.5.6, Section 2 of this Chapter, not to exceed the following:

- ~~steel with a specified minimum yield strength $R_{eH} \leq 420$ N/mm²: HV350;~~

— steel with a specified minimum yield strength $420 \text{ N/mm}^2 < R_{eH} \leq 690 \text{ N/mm}^2$;
HV420.

CHAPTER 5 WELDING OF HULL STRUCTURES

Section 3 INSPECTION AND REPAIRING OF WELDS

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

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

(2) For butt connections of longitudinals and girders at bottom, side and deck,
within 0.4L amidships — one in ten;
outside 0.4L amidships — one in twenty.

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

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

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

- a. connection of main engine foundation girders to top plate: 100%;
- b. rudder horn and shaft bracket to shell plate of hull structure: 100%;
- c. connection of rudder side plating to cast rudder stock: 100%;
- d. edge reinforcement or pipe penetration both to strength deck, sheer strake and bottom plating within 0.6L amidships, when the dimensions of the opening exceeds 300 mm: 100%;
- e. toe connections of longitudinal hatch coaming end bracket to the deck plating: within 0.6L amidships: 100%; outside 0.6L amidships—one in two;
- f. connection of inner bottom with transverse bulkheads, lower stools or transverse floors, or connection of lower stools with transverse bulkheads: 35%;
- g. connection of hopper tank sloping plates with inner bottom or inner side: 25%;
- h. connection of transverse corrugated bulkheads with topside tanks: 35%;
- i. deck stringer/sheer strake joint: 10%, and within 0.6L amidships: 1 m increase for the testing at each erection weld.

(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 2 PRODUCTION WELDING TESTS OF PRESSURE SHELLS

7.2.3.3 Where the test plate is greater than 70 mm in thickness, two deposited metal tensile test specimens are to be taken as shown in Figure 7.2.3.3. If a specimen of 10 mm diameter cannot be taken, the largest practicable diameter is to be used, and the gauge length of the test specimen is to be 5 times the diameter. For steel plates of less than 16 mm in thickness, the deposited metal tensile test may be waived.

Section 4 HEAT TREATMENT

7.4.1 General requirements

7.4.1.1 Pressure shells and their test assemblies for production welding tests are to be heat treated on completion of the welding and prior to the hydraulic test.

7.4.1.2 Post-weld heat treatment may be exempted for the following pressure shells:

(1) ~~Class I pressure shells~~ Boilers made of carbon or carbon-manganese steel and having a plate thickness ~~not exceeding less than~~ 20 mm for their welded components;

(2) ~~Class I and II boilers and pressure vessels~~ general pressure vessels made of carbon or carbon-manganese steel, having a plate thickness ~~of less than~~ not exceeding 30 mm for their welded components ~~and a working temperature not exceeding 150°C; or those made of carbon-manganese steel, having a plate thickness of less than 20 mm for their welded components and a working temperature not exceeding 150°C~~ (When steels with specified Charpy V-notch impact properties at low-temperature are used, such thickness may be increased subject to the agreement of CCS);

(3) all Class III pressure vessels.

7.4.1.3 ~~Post-weld heat treatment is to be carried out for diving systems and submersibles with plate thickness over 20 mm, which may be exempted with prior agreement of the Surveyor for pressure shells of diving systems and submersibles with plate thickness over 20 mm, provided the weld joints are proved to be of fine fracture toughness.~~