



CHINA CLASSIFICATION SOCIETY

RULES FOR MATERIALS AND WELDING

AMENDMENTS

2021

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Revision explanation

1. Blue underline is to highlight new insertions, strikethrough line is to highlight deleted contents and cross line may be used to highlight deleted tables or figures.
2. No change in the English text means that only Chinese text is editorially revised while the change of corresponding English version is not needed.

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PART ONE METALLIC MATERIALS

CHAPTER 2 MATERIAL TESTS

Section 2 TENSILE TESTS

2.2.4.1 Testing at room temperature is to comply with the following requirements:

(3) For steel, the upper yield strength is to be calculated from the following measured load values:

- ① the load immediately prior to a distinct fallback in the movement of the pointer of the testing machine or the load at a marked hesitation of this pointer;
- ② the value of load measured either at the commencement of plastic deformation at yield or at the first peak obtained during yielding even when that peak is equal to or less than any subsequent peaks observed during plastic deformation at yield, as shown in a load/extension diagram.

Section 9 PITTING CORROSION TEST FOR DUPLEX STAINLESS STEELS

2.9.1 General requirements

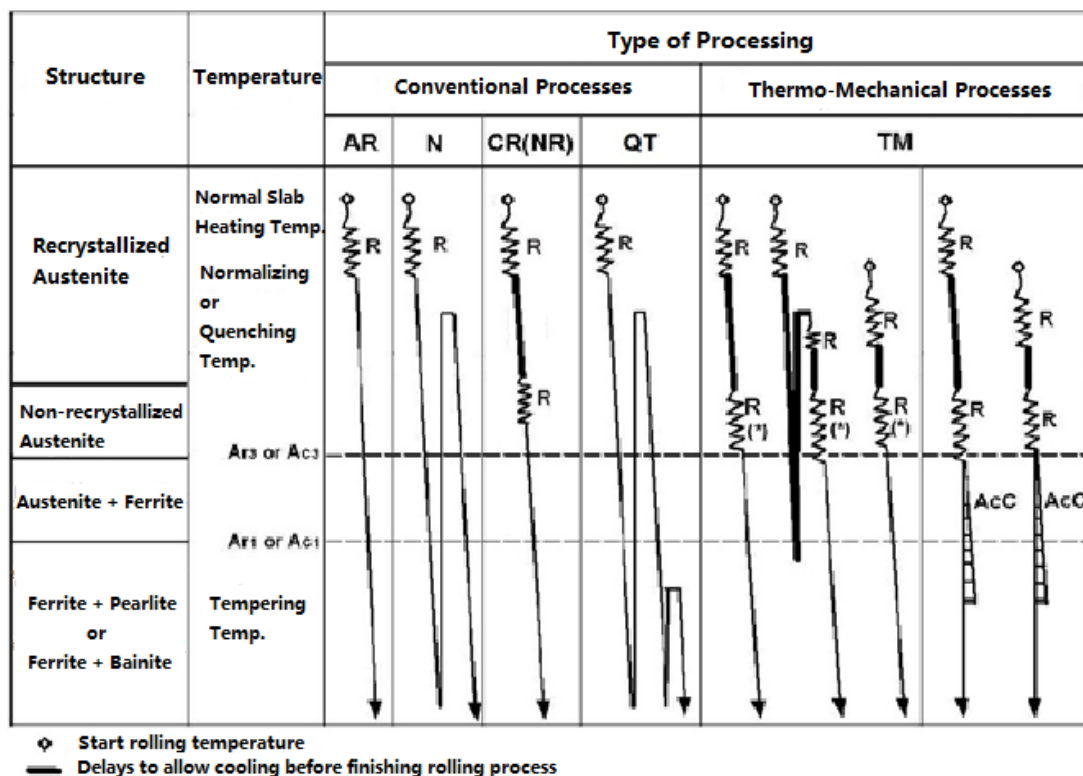
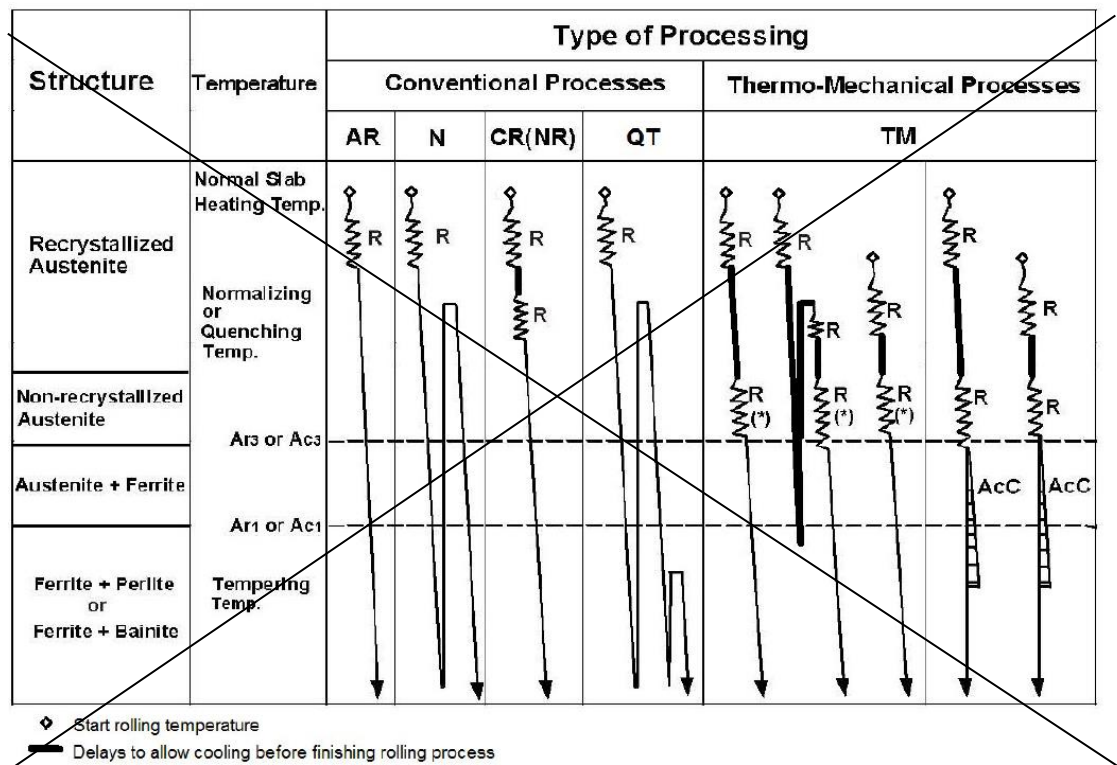
2.9.1.1 The pitting corrosion test for duplex stainless steels is mainly used to evaluate the corrosion resistance performance of austenitic/ferritic stainless steel products and weld joints.

2.9.1.2 Pitting corrosion resistance test for lean duplex stainless steel (the Ni content is generally less than 2.5%) products and welded joints that is not covered in the Rules may be conducted in accordance with relevant recognized standards (e.g. ASTM A1084-15a C method), subject to the agreement of CCS. For lean duplex stainless steel, test temperature for the base material and weld metal is 25°C.

CHAPTER 3 STEEL PLATES, FLAT BARS AND SECTIONS

Section 1 GENERAL PROVISIONS

3.1.2.4 Rolling practice and heat treatment method applied for steel is to comply with the appropriate conditions of supply as specified in relevant sections in this Chapter. The definitions of applicable rolling and heat treatment procedures are given as follows. The schematic diagram is shown in Figure 3.1.2.4.



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

Figure 3.1.2.4 Schematic diagram of steel rolling processes

Section 2 NORMAL STRENGTH HULL STRUCTURAL STEELS

3.2.4.4 For full-thickness flat [non-proportional](#) test specimens with a width of 25 mm and a gauge length of 200 mm, the minimum elongation is to comply with Table 3.2.4.4.

Minimum Elongation of Full-Thickness Flat Non-proportional Test Specimens **Table 3.2.4.4**

Thickness <i>t</i> (mm)	$t \leq 5$	$5 < t \leq 10$	$10 < t \leq 15$	$15 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 30$	$30 < t \leq 40$	$40 < t \leq 50$
Elongation A (%)	14	16	17	18	19	20	21	22

Section 3 HIGHER STRENGTH HULL STRUCTURAL STEELS

3.3.1 Grades

3.3.1.1 Higher strength hull structural steels are to be subdivided into strength levels in accordance with the specified minimum yield strength, and each strength level is further subdivided into four grades as A, D, E and F in accordance with different levels of notch toughness. The requirements of this Section apply to Grades [AH27, DH27, EH27, FH27](#), AH32, DH32, EH32, FH32, AH36, DH36, EH36, FH36, AH40, DH40, EH40 and FH40 steel plates and wide flats of thickness not exceeding 150 mm, as well as to sections and bars of the above-mentioned grades and of thickness not exceeding 50 mm.

Chemical Composition of Higher Strength Hull Structural Steels **Table 3.3.2.1**

Grade		AH27, DH27, EH27 , AH32, AH36, AH40, DH32, DH36, DH40, EH32, EH36, EH40	FH27 , FH32, FH36, FH40
Chemical composition (%) ^{⑤⑥}	C	≤ 0.18	≤ 0.16
	Mn	$0.90 \sim 1.60^{①}$	$0.90 \sim 1.60^{②}$
	Si	≤ 0.50	≤ 0.50
	S	≤ 0.035	≤ 0.025
	P	≤ 0.035	≤ 0.025
	Al(acid soluble)	$\geq 0.015^{②③}$	$\geq 0.015^{②③}$
	Nb ^④	$0.02 \sim 0.05^{③}$	$0.02 \sim 0.05^{③}$
	V ^④	$0.05 \sim 0.10^{③}$	$0.05 \sim 0.10^{③}$
	Ti ^④	≤ 0.02	≤ 0.02
	Cu	≤ 0.35	≤ 0.35
	Cr	≤ 0.20	≤ 0.20
	Ni	≤ 0.40	≤ 0.80
	Mo	≤ 0.08	≤ 0.08
	N	—	≤ 0.009 (≤ 0.012 if Al is present)

Notes: ① For steels up to 12.5 mm in thickness [and Grades AH27, DH27, EH27 and FH27 steels](#), the minimum manganese content may be reduced to 0.70%.

② The total aluminium content may be determined instead of the acid soluble content. In such cases the total aluminium content is to be not less than 0.02%.

③ The steel is to contain suitable grain refining elements (Al, Nb, V, etc.), either singly or in any combination. When used singly, the steel is to contain the specified minimum content of the grain refining element; and when used in combination, the specified minimum content of each element is not applicable. However, the approved technical conditions are to be satisfied.

④ The contents of Nb, V and Ti are, in addition, to comply with $Nb\% + V\% + Ti\% \leq 0.12\%$.

⑤ Where the steel is supplied in TMCP condition, the chemical composition is to comply with 3.3.2.3 of this Section.

⑥ Where any other element has been added as part of the steelmaking practice, the content is to be stated in the certificate.

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

Table 3.3.2.3(1)

Grade	Carbon equivalent ^① C_{eq} (%)		
	thickness <i>t</i> (mm)		
	$t \leq 50$	$50 < t \leq 100$	$100 < t \leq 150$
AH27, DH27, EH27, FH27	≤0.36	≤0.38	≤0.40
AH32, DH32, EH32, FH32	≤ 0.36	≤ 0.38	≤ 0.40
AH36, DH36, EH36, FH36	≤ 0.38	≤ 0.40	≤ 0.42
AH40, DH40, EH40, FH40	≤ 0.40	≤ 0.42	≤ 0.45

Note: ① It is a matter for the manufacturer and the shipbuilder to mutually agree in individual cases as to whether they wish to specify a more stringent carbon equivalent.

3.3.3.1 Steels are to be supplied in conditions complying with Table 3.3.3.1.

Condition of Supply for Higher Strength Hull Structural Steel

Table 3.3.3.1

Grade	Grain refining element	Product	Condition of supply (batch weight for impact test) ^{①②}					
			thickness t (mm)					
			$t \leq 12.5$	$12.5 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 35$	$35 < t \leq 50$	$50 < t \leq 150$
AH27 AH32 AH36	Nb and/or V	Plates	A(50)	N(50), CR(50), TM(50)				N(50), CR(25), TM(50)
		Sections	A(50)	N(50), CR(50), TM(50), AR [*] (25)				Not applicable
	Al or Al and Ti	Plates	A(50)		AR [*] (25)		Not applicable	
				N(50), CR(50), TM(50)		N(50), CR(25), TM(50)		
		Plates	A(50)	N(50), CR(50), TM(50), AR [*] (25)				Not applicable
AH40	Any	Plates	A(50)	N(50), CR(50), TM(50)				N(50), TM(50), QT (each length heat treated)
		Sections	A(50)	N(50), CR(50), TM(50)				Not applicable
DH27 DH32 DH36	Nb and/or V	Plates	A(50)	N(50), CR(50), TM(50)				N(50), CR(25), TM(50)
		Sections	A(50)	N(50), CR(50), TM(50), AR [*] (25)				Not applicable
	Al or Al and Ti	Plates	A(50)		AR [*] (25)		Not applicable	
				N(50), CR(50), TM(50)		N(50), CR(25), TM(50)		
		Sections	A(50)	N(50), CR(50), TM(50), AR [*] (25)				Not applicable
DH40	Any	Plates	N(50), CR(50), TM(50)					N(50), TM(50), QT (each length heat treated)
		Sections	N(50), CR(50), TM(50)					Not applicable
EH27 EH32 EH36	Any	Plates	N (each piece), TM (each piece)					
		Sections	N(25), TM(25), AR [*] (15), CR [*] (15)					Not applicable
EH40	Any	Plates	N (each piece), TM (each piece), QT (each length heat treated)					
		Sections	N(25), TM(25), QT(25)					Not applicable
FH27 FH32 FH36	Any	Plates	N (each piece), TM (each piece), QT (each length heat treated)					
		Sections	N(25), TM(25), QT(25), CR [*] (15)					Not applicable
FH40	Any	Plates	N (each piece), TM (each piece), QT (each length heat treated)					
		Sections	N (25), TM (25), QT (25)					Not applicable

Notes: ① Condition of supply: A: any; N: normalized; CR: controlled rolled; TM (TMCP): thermomechanically controlled-rolled; QT: quenched and tempered; AR*: as-rolled condition subject to special approval of CCS; CR*: controlled rolled condition subject to special approval of CCS.

② The number in parentheses denotes the batch weight for impact test (in t). One set of three Charpy V-notch test specimens is to be taken from each batch weight or fraction thereof.

3.3.4.3 The mechanical properties of higher strength hull structural steels are to comply with Table 3.3.4.3.

Mechanical Properties of Higher Strength Hull Structural Steel

Table 3.3.4.3

Grade	Yield strength R_{eH} min. (N/mm ²)	Tensile strength R_m (N/mm ²)	Elongation A_5 min. (%)	Charpy V-notch impact test ^①						
				Test temp. (°C)	Average energy min. (J)					
					Thickness t (mm)					
					$t \leq 50$		$50 < t \leq 70$		$70 < t \leq 150$	
				Long.	Trans.	Long.	Trans.	Long.	Trans.	
AH27	265	410 ~ 530	22	0	27^②	20^②	34	24	42	27
DH27				-20						
EH27				-40						
FH27				-60						
AH32	315	440 ~ 570	22	0	31 ^②	22 ^②	38	26	46	31
DH32				-20						
EH32				-40						
FH32				-60						
AH36	355	490 ~ 630	21	0	34 ^②	24 ^②	41	27	50	34
DH36				-20						
EH36				-40						
FH36				-60						
AH40	390	510 ~ 660	20	0	39	26	46	31	55	37
DH40				-20						
EH40				-40						
FH40				-60						

Notes: ① Generally, impact tests need only be made in the longitudinal direction, except when required by the purchaser or CCS; however, satisfactory transverse test results for plates and wide flats are to be

guaranteed by the manufacturer. Generally, impact tests need only be made in the longitudinal direction for sections.

- ② For Grades [AH27](#), AH32 and AH36 steels, a relaxation in the number of impact tests for acceptance purposes may be permitted by CCS provided that satisfactory results are obtained from occasional check tests.

3.3.4.4 For full-thickness flat [non-proportional](#) test specimens with a width of 25 mm and a gauge length of 200 mm, the minimum elongation is to comply with Table 3.3.4.4.

Minimum Elongation of Full-Thickness Flat [Non-proportional](#) Test Specimens **Table 3.3.4.4**

Thickness <i>t</i> (mm)	Grade	$t \leq 5$	$5 < t \leq 10$	$10 < t \leq 15$	$15 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 30$	$30 < t \leq 40$	$40 < t \leq 50$
Elongation <i>A</i> (%)	AH27, DH27, EH27, FH27	14	16	17	18	19	20	21	22
	AH32, DH32, EH32, FH32	14	16	17	18	19	20	21	22
	AH36, DH36, EH36, FH36	13	15	16	17	18	19	20	21
	AH40, DH40, EH40, FH40	12	14	15	16	17	18	19	20

Section 7 STEELS FOR LOW TEMPERATURE SERVICE

Conditions of supply and mechanical properties of nickel alloy steel **Table 3.7.3.2**

Grade	Condition of supply	Proof strength $R_{p0.2}$ min. (N/mm2)	Tensile strength R_m (N/mm ²)	Elongation A_5 min. (%)	Charpy V-notch impact tests			Design Temp. min. (°C)	
					Material thickness t (mm)	Test Temp. T (°C)	Average energy of test specimens, min. (J)		
							Long.		Trans.
1.5Ni	Normalized or normalized and tempered or quenched and tempered or TMCP ^①	275	470~640	22	$t \leq 25$ $25 < t \leq 30$ $30 < t \leq 35$ $35 < t \leq 40$	-65 -70 -75 -80	41	27	-60
2.25Ni	Normalized or normalized and tempered or quenched and tempered or TMCP ^①	295	420~570	19	$t \leq 25$ $25 < t \leq 30$ $30 < t \leq 35$ $35 < t \leq 40$	-70 -75 -80 -85			-65
3.5 Ni		345	440~690	21	$t \leq 25$ $25 < t \leq 30$ $30 < t \leq 35$ $35 < t \leq 40$	-95 -100 -105 -110			-90
5Ni	Normalized or normalized and tempered or quenched and tempered ^{①②}	390	520~710	21	$t \leq 25$ $25 < t \leq 30$ $30 < t \leq 35$ $35 < t \leq 40$	-110 -115 -120 -125			-105
9Ni	Double normalized and tempered or quenched and tempered	490	640~830	19	$t \leq 40$	-196			-165

① Nickel steel supplied in TMCP is subject to agreement of CCS.

② Nickel steel with 5% Ni content after being subject to special heat treatment, such as three stage heat treatment (double quenched and tempered), may be used in locations where the minimum temperature is -165°C. However, impact tests are to be carried out at temperature below -196°C.

③ The requirement is applicable to materials not over 40 mm in thickness. For materials over 40 mm in thickness, the energy value of Charpy V-notch impact test is subject to agreement of CCS.

④ The transverse values of impact tests apply to plates and the longitudinal values to sections.

3.7.3.3 Preparation of the specimens for mechanical tests

- (1) For plates: one tensile test specimen and a set of three impact test specimens are to be taken from one end of each rolled piece.
- (2) For sections and other steels: one tensile test specimen and a set of three impact test specimens are to be taken from one piece in each batch with similar dimensions, originating from the same heat treatment charge and the same heat of steel by the same rolling procedure. The mass of each batch is not to exceed 10t.
- (3) The direction of cut, shape and dimensions of the tensile and impact test specimens are to comply with the relevant requirements of Chapter 2 of this PART and Section 1 of this Chapter. For plates intended for the applications as detailed in 3.7.1.1 above, transverse specimens are to be taken for impact tests. The locations where the specimens are taken and the test values are to be in accordance with the relevant requirements of [6.3.1, 6.3.2 and 6.4.1, Chapter 6 6.1.4.1, 6.1.4.2 and 6.1.5, Chapter 6](#) of CCS Rules for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

Section 8 AUSTENITIC AND DUPLEX STAINLESS STEELS

3.8.1 Application

3.8.1.1 This Section applies to austenitic stainless steels, austenitic/ferritic duplex stainless steels (hereinafter referred to as duplex stainless steels) [and lean austenitic/ferritic duplex stainless steels \(hereinafter referred to as lean duplex stainless steels\)](#) intended for use in the construction of cargo tanks, process pressure vessels for oil, gas and water as well as other components of bulk chemical tankers and liquefied gas carriers.

[3.8.1.2 In design, construction, carriage of cargo and operation of bulk chemical carriers, the difference between the pitting corrosion resistance performance of lean duplex stainless steel and duplex stainless steel is to be considered. The design, construction, cargo list and in-serve survey requirements of chemical tankers using lean duplex stainless steel is to be subject to special consideration by CCS.](#)

3.8.2 General requirements

3.8.2.1 The austenitic stainless steels covered by this Section may also be used for the construction of pressure vessels where the design temperature is not lower than -165°C. [In cases where the steels are used at elevated temperatures, the corrosion in the environment is to be considered and to be subject to agreement of CCS.](#)

3.8.2.2 The duplex stainless steels covered by this Section may generally be used for the construction of structural members where the design temperature is [not lower than 0°C to 300°C. The design temperature of duplex stainless steels designed for use in salt spray environments is not to exceed 100°C.](#)

~~3.8.2.3 The austenitic stainless steels are also suitable for service at elevated temperatures and for such applications, details of the chemical composition, mechanical properties at both ambient and working temperatures, and heat treatment are to be submitted to CCS.~~

[3.8.2.3 Where it is proposed to use lean duplex stainless steels, particulars of the chemical composition, mechanical properties, heat treatment procedures and pitting corrosion resistance performance are to be submitted to CCS for approval.](#)

3.8.5.2 Unless otherwise agreed, all grades of austenitic stainless steel given in this Section may generally be exempted from impact tests. Where austenitic stainless steel is to be used at a working temperature of -100°C or lower, Charpy V-notch impact tests at -196°C [are to be carried out may be required](#). The minimum average energy values of the impact tests are to be no less than 27 J (transverse).

3.8.6 Intergranular corrosion tests

3.8.6.1 When stainless steels [\(austenitic stainless steels, duplex stainless steels and lean duplex stainless steels\)](#) are used for certain environment, such as tanks or storage tanks containing corrosive chemicals, test specimens are to be taken and tested together with those for tensile tests according to the requirements in 3.5.4.1 of this Chapter for a set or batch of specimens.

3.8.7 Pitting corrosion test

3.8.7.1 Duplex stainless steel specimens for pitting corrosion tests are to be taken and tested together with those for tensile tests according to the requirements in 3.5.4.1 of this Chapter for a set or batch of specimens.

3.8.7.2 The specimens for duplex stainless steel pitting corrosion tests are to be prepared and tested in compliance with Section 9, Chapter 2 of this PART.

3.8.7.3 The specimens for lean duplex stainless steel pitting corrosion tests are to be prepared and tested by referring to ASTM A1084-15a C method, after being specially considered and agreed by CCS.

Section 9 CLAD STEEL PLATES

3.9.6.5 One transverse test specimen for shear test is to be prepared from each plate, and is to be tested in accordance with relevant standards recognized by CCS. The shearing strength of the bonding is not to be less than the values specified as follows:

(1) For plates having a tensile strength $R_m < 280 \text{ N/mm}^2$, the shearing strength is to be 50% of the tensile strength.

(2) For plates having a tensile strength $R_m \geq 280 \text{ N/mm}^2$, the shearing strength is to be 140 N/mm^2 .

Section 12 ROLLED STEEL BARS FOR ANCHOR CHAIN CABLES AND ACCESSORIES

3.12.1 General requirements

3.12.1.1 This Section applies to rolled steel bars intended for anchor chain cables, offshore mooring chains and accessories.

3.12.1.2 The rolled steel bars intended for chain cables are subdivided into eight-nine grades, i.e. M1, M2 and M3 for chain steels and MR3, MR3S, MR4, MR4S, ~~and~~ MR5 and MR6 for offshore mooring chain steels, depending on the nominal tensile strength and applicable product types.

3.12.2 Chemical composition

3.12.2.1 For grades M1, M2 and M3 chain steels, the chemical composition is normally to be in compliance with the requirements of Table 3.12.2.1.

Deoxidation and Chemical Composition of Steel Bars

Table 3.12.2.1

Grade	Deoxidation method	Chemical composition (%)					
		C	Si	Mn	P	S	Al ^②
M1	Killed	≤ 0.20	0.15~0.35	≥ 0.40	≤ 0.040	≤ 0.040	—
M2 ^①	Killed and fine grain treated	≤ 0.24	0.15~0.55	≤ 1.60	≤ 0.035	≤ 0.035	≥ 0.020
M3	Killed and fine grain treated	Specification acceptable to CCS ^③					

Notes: ① If agreed by CCS, alloying elements may be added.

② It means the total aluminum content. Al may be replaced partly by other grain refining elements.

③ For grade M3 chain steels, the manufacturer is to provide relevant specification which includes all necessary details, such as chemical composition, means of deoxidation, manufacturing procedures, heat treatment requirements and mechanical properties.

3.12.2.2 The chemical composition of offshore mooring chain steels is to comply with recognized standards, but for grades MR4, MR4S, ~~and~~ MR5 and MR6 chain, the steels are to contain a minimum of 0.20% molybdenum.

3.12.3 Manufacture

3.12.3.1 The rolled steel bars intended for chain cables, mooring chains and accessories are to be provided by the works approved by CCS, except for steel intended for grade 1 chain cables.

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.

3.12.3.3 All chain steels and mooring chain steels are to be killed and except for grade M1 chain steels, other chain steels and mooring chain steels are to be fine grain treated.

3.12.3.4 Grade MR4S, ~~and~~ MR5 and MR6 mooring chain steels are to be vacuum degassed.

3.12.3.5 The rolling reduction ratio of steel intended for mooring chains is to be at least 5:1. If required by the contract, the rolling reduction ratio used in production can be higher. The rolling

reduction ratio means the ratio of sectional area of initial steel to that of finished steel.

3.12.3.6 Except as agreed in the contract, steel bars intended for chains are usually supplied in the as-rolled condition.

3.12.4 Chemical analysis and metallurgical examination

3.12.4.1 The chain steels and mooring chain steels are to be subject to analysis of the chemical composition of each ladle, and the results obtained are to comply with the requirements of 3.12.2 of this Section.

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 For steels of grades MR4S, ~~and~~ MR5 ~~and~~ MR6, the following information is to be supplied by the bar manufacturer to the mooring chain manufacturer and the results included in the chain documentation:

(1) Non-metallic inclusions: non-metallic inclusions of each heat are 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) Jominy hardenability test: a sample from each heat is to be tested in accordance with a recognized standard (e.g. ASTM A255).

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	≥ 690 ^③	≥ 17	50	0(-20) ^②	≥ 60(40)
MR3S	≥ 490	≥ 770 ^③	≥ 15	50	0(-20) ^②	≥ 65(45)
MR4	≥ 580	≥ 860 ^③	≥ 12	50	-20	≥ 50
MR4S ^④	≥ 700	≥ 960 ^③	≥ 12	50	-20	≥ 56
MR5 ^④	≥ 760	≥ 1000 ^③	≥ 12	50	-20	≥ 58
MR6 ^⑤	≥ 900	≥ 1100 ^⑤	≥ 12	50	-20	≥ 60

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 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.

⑤ Aim value of yield to tensile ratio: 0.95 max.

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.

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 heat treatment simulated 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 ~~and~~ MR6 bars intended for mooring chains, the certificate is to contain the results of

hydrogen embrittlement test, non-destructive testing, etc., and the information of austenitic grain size, non-metallic inclusions and hardenability.

CHAPTER 4 STEEL PIPES AND TUBES

Section 1 GENERAL PROVISIONS

4.1.8.2 The hydraulic test is to be carried out as follows:

(1) The test pressure is to be twice the working pressure of the pipe, and is not to be less than 7.0 MPa. If required by the purchaser, the test pressure may be as specified in the contract, provided that the details are submitted to CCS for information.

(2) The test pressure P mentioned in (1) above need not exceed the value calculated by the following formula:

$$P = 2t\sigma_t / D \quad \text{MPa}$$

where: D — nominal outside diameter of the pipe, in mm;

t — nominal wall thickness of the pipe, in mm;

σ_t — permissible stress, in MPa; for carbon steel pipes, R is to be taken as 80% of the minimum yield strength (R_{eH} or $R_{p0.2}$); for austenitic [and duplex](#) steel pipes, 80% of the minimum proof strength ($R_{p0.2}$).

(3) The test pressure is to be maintained for sufficient time to permit inspection.

Section 6 AUSTENITIC AND AUSTENITIC/FERRITIC DUPLEX STAINLESS STEEL PRESSURE PIPES

4.6.1.1 The requirements of this Section apply to austenitic stainless steel pressure pipes where the design temperature is not less than -165°C and austenitic stainless steel and austenitic/ferritic duplex stainless steel pressure pipes used in corrosive environment. [In cases where the pipes are used at elevated temperatures, the corrosion in the environment is to be considered and to be subject to agreement of CCS.](#)

4.6.1.2 Austenitic stainless steel pressure pipes are also suitable for service at elevated temperatures. When such applications are proposed, details of the chemical composition, mechanical properties and heat treatment are to be submitted to CCS for approval.

4.6.1.3 Austenitic/ferritic duplex stainless steels are generally used where the design temperature is [not lower than between 0°C to 300°C. The design temperature of duplex stainless steels designed for use in salt spray environments is not to exceed 100°C.](#)

[4.6.1.4 Duplex stainless steel pipes having direct contact with chemicals are to be subject to pitting corrosion test in accordance with the requirements in Section 9 of Chapter 2 of The Rules.](#)

4.6.4.2 Unless otherwise agreed, austenitic stainless steel pipes listed in this Section are generally not required to be impact tested. Where austenitic stainless steel pipes (seamless and welded) are used in working temperature at -100°C and below, and where the wall thickness allows standard impact specimens the width of which is 5 mm or greater to be taken, Charpy V-notch impact tests at temperature below -196°C [are to be carried out may be required](#). The minimum average value of the test is not to be lower than 41 J (specimen taken longitudinally).

CHAPTER 5 STEEL FORGINGS

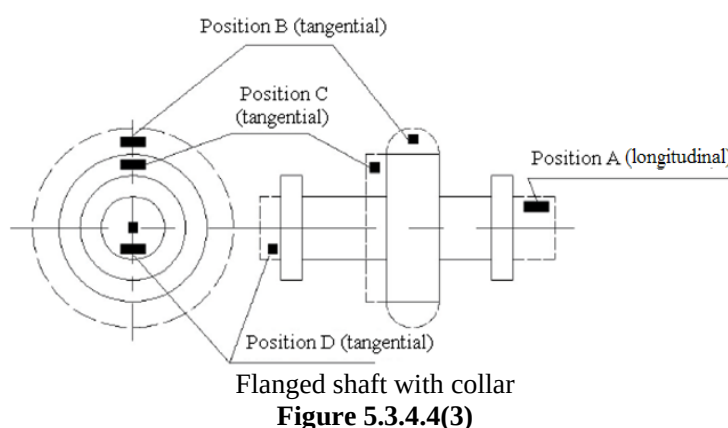
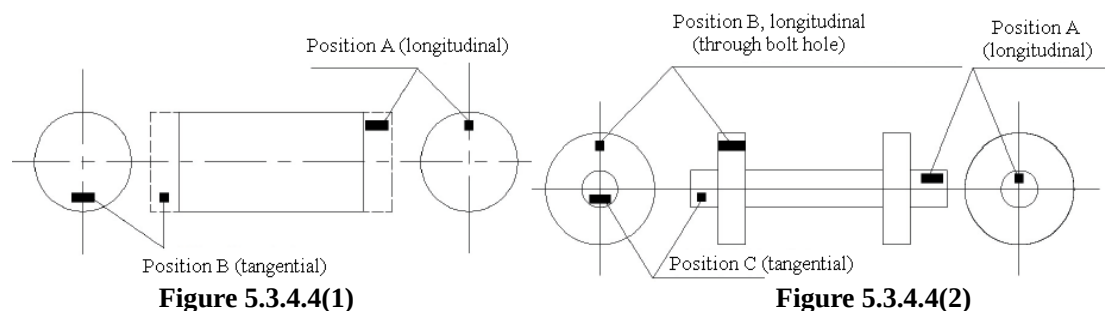
Section 1 GENERAL PROVISIONS

5.1.1.4 Forgings [and rolled bars used as a substitute for 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.

Section 3 FORGINGS FOR SHAFTING AND MACHINERY

5.3.4.4 The test specimens are in general to be taken in the longitudinal direction (position A),

but the manufacturer may use alternative directions or positions as shown in Figures 5.3.4.4(1), (2) and (3).



Section 5 FORGINGS FOR GEARING

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

(1) For pinion forgings where the finished diameter of the toothed portion exceeds 200 mm, test specimens are to be taken in a tangential direction and adjacent to the toothed portion (test position B in Figure 5.5.5.1(1)). Where the dimensions preclude the preparation of test specimens from position B, specimens in a tangential direction are to be taken from the end of the journal (test position C in Figure 5.5.5.1(1)). If, however, the journal diameter does not exceed 200 mm, test specimens are to be taken in a longitudinal direction (test position A in Figure 5.5.5.1(1)). Where the finished length of the toothed portion exceeds 1.25 m or the finished weight of the gear exceeds 4 tonnes, test specimens are to be taken from each end.

5.5.6.3 Small gear forgings may be batch tested in accordance with the requirements of 5.1.5.23 of this Chapter, but at least one hardness test is to be carried out on each forging.

Section 6 FORGINGS FOR TURBINES

5.6.5.2 For turbine forgings in alloy steel, the mechanical properties after quenching and tempering or normalizing and tempering are to comply with the requirements of Table 5.6.5.2.

Mechanical Properties of Alloy Steel Forgings for Turbines **Table 5.6.5.2**

Tensile strength R_m min. (N/mm ²)	Yield strength R_{eH} or $R_{p0.2}$ min. (N/mm ²)		Elongation A_5 min. (%)			Reduction of area Z min. (%)		
	Normalized and tempered	Quenched and tempered	Long.	Tang.	Radial	Long.	Tang.	Radial
500	275	—	22	20	18	50	40	35
550	300	—	20	18	16	50	40	35
600	330	410	18	16	14	50	40	35
650	355	450	17	15	13	50	40	35

700	385	490	16	14	12	45	35	30
750	—	530	15	13	11	45	35	30
800	—	590	14	12	10	45	35	30
850	—	640	13	11	9	40	30	25
900	—	690	13	11	9	40	30	25
950	—	750	12	10	8	40	30	25
1000	—	810	12	10	8	40	30	25

- Notes: ① Test specimens are to be taken in the directions as indicated in Figures 5.6.4.1(1) and (3).
 ② For intermediate values of tensile strength, the minimum values of R_m , R_{eH} or $R_{p0.2}$, A_5 and Z may be obtained by interpolation.
 ③ For all grades of forgings in the Table, the tensile strength range is 150 N/mm².
 ④ For monobloc rotor forgings, the tensile strength is not to exceed 800 N/mm².

Section 7 FORGINGS FOR BOILERS, PRESSURE VESSELS AND PIPING SYSTEMS

Mechanical Properties of Forgings for Boilers, Pressure Vessels and Piping Systems

Table 5.7.5.1

Steel type	Diameter or equivalent thickness t (mm)	Tensile strength R_m min. (N/mm ²)	Yield strength R_{eH} min. (N/mm ²)	Elongation A_5 min. (%)	Hardness (HB)
Carbon and carbon-manganese steel	$t \leq 63$	410	215	20	110 ~ 155
	$63 < t \leq 250$		205		
	$t \leq 63$	460	245	18	130 ~ 170
	$63 < t \leq 250$		235		
	$t \leq 63$	490	265	16	140 ~ 180
	$63 < t \leq 250$		255		
Carbon and carbon-manganese steel, fine grained	$t \leq 63$	410	235	20	110 ~ 155
	$63 < t \leq 250$		220		
	$t \leq 63$	460	275	18	130 ~ 170
	$63 < t \leq 250$		255		
	$t \leq 63$	490	305	16	140 ~ 180
	$63 < t \leq 250$		280		
1Cr0.5Mo	$t \leq 100$	410	255	18	110 ~ 160
2.25Cr1Mo	$t \leq 100$	490	275	18	140 ~ 185

- Notes: ① For intermediate values of tensile strength, the minimum values for R_{eH} and A_5 may be obtained by interpolation.
 ② For all grades of carbon and carbon-manganese steel in the Table, the tensile strength range is 120 N/mm²; for alloy steel, the tensile strength range is 150 N/mm².
 ③ Where test specimens are taken from each end of the forgings, the variation in tensile strength is not to exceed 70 N/mm².
 ④ The hardness values are only applicable for each piece of small batch-tested forgings.

Section 9 AUSTENITIC AND DUPLEX STAINLESS STEEL FORGINGS

5.9.4.3 Unless otherwise agreed, impact test is generally not required for austenitic [stainless steel](#) forgings. When austenitic stainless steel [forgings are](#) used at temperatures equal to or lower than -100°C, Charpy V-notch impact test at -196°C [is to be carried out](#). The average value of test results is not to be lower than 41 J (axes of specimens parallel to the final direction of rolling) [or 34 J \(axes of specimens perpendicular to the final direction of rolling\)](#).

CHAPTER 6 STEEL CASTINGS

Section 2 CASTINGS FOR HULL STRUCTURES

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

8.2.5.9 Where the results of any tensile test are not in accordance with the requirements, re-tests for acceptance may be carried out in accordance with the requirements given in 1.2.56 of Chapter 1 of this PART.

8.2.7.2 Mechanical properties for extruded products in various temper conditions are to be in accordance with the requirements given in Table 8.2.7.2.

Mechanical Properties for Extruded Aluminum Alloy Products **Table 8.2.7.2**

Designation	Temper condition	Thickness t mm	Proof strength $R_{p0.2}$ (N/mm ²)	Tensile strength R_m (N/mm ²)	Minimum elongation A ^{①②} (%)	
					50 mm	5d
5A01	H112	$3 \leq t \leq 50$	≥ 170	≥ 330	10	
5454	H112	$3 \leq t \leq 50$	≥ 100	≥ 230	10	
5083	O	$3 \leq t \leq 50$	≥ 110	270 ~ 350	14	12
	H111	$3 \leq t \leq 50$	≥ 165	≥ 275	12	10
	H112	$3 \leq t \leq 50$	≥ 110	≥ 270	12	10
5383	O	$3 \leq t \leq 50$	≥ 145	≥ 290	17	17
	H111	$3 \leq t \leq 50$	≥ 145	≥ 290	17	17
	H112	$3 \leq t \leq 50$	≥ 190	≥ 310		13
5059	H112	$3 \leq t \leq 50$	≥ 200	≥ 330		10
5086	O	$3 \leq t \leq 50$	≥ 95	240 ~ 315	14	12
	H111	$3 \leq t \leq 50$	≥ 145	≥ 250	12	10
	H112	$3 \leq t \leq 50$	≥ 95	≥ 240	12	10
5456	H112	$3 \leq t \leq 50$	≥ 130	≥ 300	10	
5754	H112	$3 \leq t \leq 50$	≥ 80	≥ 180	10	
6005A	T5	$3 \leq t \leq 50$	≥ 215	≥ 260	9	8
	T6	$3 \leq t \leq 10$	≥ 215	≥ 260	8	6
		$10 < t \leq 50$	≥ 200	≥ 250	8	6
6061	T6	$3 \leq t \leq 50$	≥ 240	≥ 260	10	8
6082	T5	$3 \leq t \leq 50$	≥ 230	≥ 270	8	6
	T6	$3 \leq t \leq 5$	≥ 250	≥ 290	6	
		$5 < t \leq 50$	≥ 260	≥ 310	10	8

Notes: ① Elongation in 50 mm applies to thicknesses up to and including 12.5 mm and in 5d to thicknesses over 12.5 mm.

② The values are applicable to both longitudinal and transverse tensile test specimens.

③ [Mechanical properties of aluminum alloys with thickness \$t\$ less than 3 mm are to meet recognized standards and be subject to agreement of CCS.](#)

CHAPTER 10 EQUIPMENT

Section 1 ANCHORS

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

Table 10.1.5.4(1)

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

Type		Ordinary anchor	High holding power anchor	Super high holding power anchor
Method			(if deemed necessary by the Surveyor)	Feeders and risers of castings; Repairs by welding of all anchors; Highly stressed areas (if deemed necessary by the Surveyor)

Note: Non-destructive tests for steel castings are to be in accordance with the requirements in Sections 1 and 2, Chapter 65 of this PART. Non-destructive tests for steel forgings are to be in accordance with the requirements in Sections 1 and 2, Chapter 56 of this PART. Welds of fabricated steel anchors are to be in accordance with the relevant quality requirements.

Section 2 MARINE ANCHOR CHAIN CABLES AND ACCESSORIES

10.2.7.7 Where the mechanical properties of links in a length are not satisfactory, specimens may be taken again for retest in accordance with the requirements of Sections 1.2.6, 2 and 3, Chapter 12 of this PART.

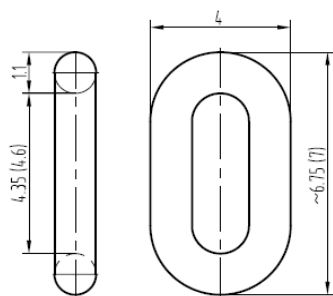


Figure 10.2.3.2(3) End link

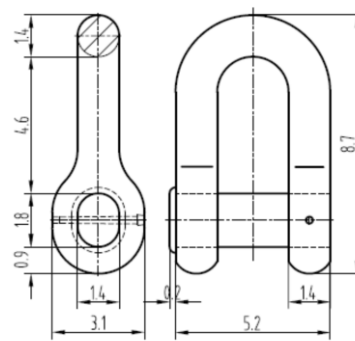


Figure 10.2.3.2(6) End shackle

10.2.8.2 Breaking load test: From each manufacturing batch (the same cast, diameter and heat treatment) of 25 units or less of shackles, swivels, swivel shackles, enlarged links and end links and from each manufacturing batch of 50 units or less of Kenter shackle, one unit is to be subjected to the breaking load test at the break load specified in Table 10.2.7.2. Parts tested in this way may not be put to further use.

Enlarged links and end links need not be tested provided that they are manufactured and heat treated together with the chain cable.

Section 3 OFFSHORE MOORING CHAINS AND ACCESSORIES

10.3.2 Chain grades

10.3.2.1 Depending on the nominal tensile strength of the steels used for manufacture, chains are to be subdivided into five six grades, i.e.: R3, R3S, R4, R4S, ~~and~~ R5 and R6.

10.3.2.2 Manufacturers' propriety specifications for R4S, ~~and~~ R5 and R6 may vary subject to design conditions and the acceptance of CCS.

10.3.3 Material

10.3.3.1 The rolled steel bars intended for welded mooring chains and accessories are to comply with the relevant requirements of Section 10, Chapter 3 of this PART.

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 MR4S, and MR5 and MR6 chain is to be vacuum degassed.

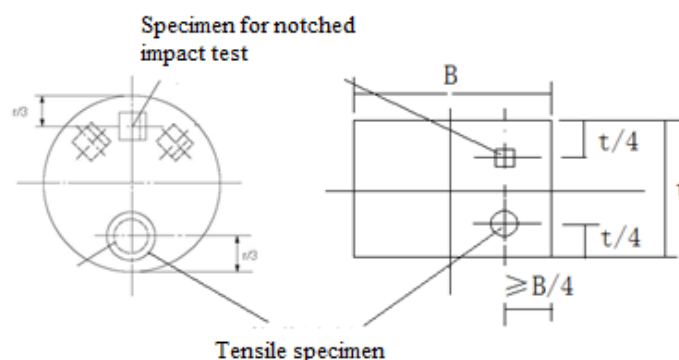
(2) The steel manufacturer is to determine the chemical composition of every heat of material. The chemical composition is to comply with the specifications acceptable to CCS at the time of approval.

(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~~ and R6 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.

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

(6) 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 of Section 12, Chapter 3 of this PART 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~~ and R6 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. 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.

(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~~ and R6 chain is to be vacuum degassed.

(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 and R6 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.

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

(6) 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 3.12.5.2 of Section 12, Chapter 3 of this PART and 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 R3S and 35% for grades R4, R4S, ~~and~~ R5 and R6.

(7) 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 forged and cast steels for grades R4S, ~~and~~ R5 and R6 accessories, in addition to routine steel information, the following information is to be included in the accessory documentation: non-metallic inclusions, segregation or porosity, jominy hardenability and ultrasonic examination, 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. 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.

10.3.6 Fitting of studs

10.3.6.1 A welded stud may be accepted for grade R3 and R3S chains. Welding of studs in grades R4, R4S, ~~and~~ R5 and R6 chains is not permitted unless specially approved by CCS.

10.3.6.2 Where studs are welded into the links, this is to be completed before the final heat

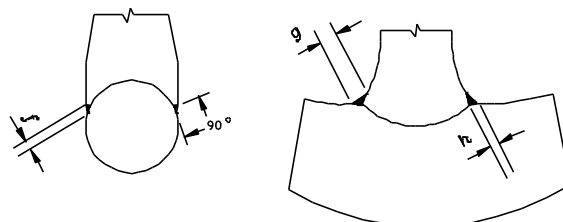
treatment of chain.

10.3.6.3 The stud ends are to be a good fit inside the link and the weld is to be confined to the stud end opposite to the flash butt weld. The full periphery of the stud end is to be welded unless otherwise approved.

10.3.6.4 Welding of the stud's both ends is not permitted unless specially approved.

10.3.6.5 The welds are to be made by qualified welders using an approved procedure and approved low-hydrogen consumables.

10.3.6.6 The size of the fillet weld is to comply with the requirements of Figure 10.3.6.6.



$$f = 0.1d_{-0.01d}^0, g = 0.2d_{-0.02d}^0, h = 0.09d_{-0.01d}^0$$

Figure 10.3.6.6

10.3.6.7 The welds are to be of good quality and free from defects such as cracks, lack of fusion, gross porosity and undercuts exceeding 1 mm.

10.3.6.8 All stud welds are to be visually examined. At least 10 per cent of all stud welds within each length of chain are to be examined by dye penetrant or magnetic particles after proof testing. If cracks or lack of fusion are found, all stud welds in that length are to be examined.

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.

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

Stud link	R3	R3S	R4	R4S	R5	R6
Proof test load (kN)	0.0148K	0.0180K	0.0216K	0.0240K	0.0251K	0.0276K
Break test load (kN)	0.0223K	0.0249K	0.0274K	0.0304K	0.0320K	0.0352K
Studless	R3	R3S	R4	R4S	R5	R6
Proof test load (kN)	0.0148K	0.0174K	0.0192K	0.0213K	0.0223K	0.0246K
Break test load (kN)	0.0223K	0.0249K	0.0274K	0.0304K	0.0320K	0.0352K
Chain weight (kg/m)	Stud link = $0.0219d^2$		Studless chain Weight calculated for each design			
Length L over 5 links	$22d \leq L \leq 22.55d$					

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

d —nominal chain diameter, in mm.

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.

(2) 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(2) 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.

(3) 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.

(4) The test results are to comply with the requirements of Table 10.3.8.8(4).

Mechanical Properties of Mooring Chains and Accessories Table 10.3.8.8(4)

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
<u>R6^④</u>	<u>≥900</u>	<u>≥1100^④</u>	<u>≥12</u>	<u>50</u>	<u>-20</u>	<u>≥60</u>	<u>≥44</u>

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.

④ Aim value of yield to tensile ratio: 0.95 max.

Section 4 STEEL WIRE ROPES

10.4.4.6 Breaking test of completed ropes is to be carried out in accordance with the following requirements:

(1) For ropes having a manufactured length less than 10,000 m, a section of test sample is to be cut from the end of each rope for breaking tests. The sample is to be of a sufficient length to provide a clear test length of at least 30 times the rope diameter between the grips. Where the manufactured length is more than 10,000 m, a second test sample is to be taken from the rope and tested.

(2) During testing, the application of breaking load on the testing machine is to be well controlled. Not more than four-fifths of the nominal breaking load is to be applied quickly, and thereafter the load is to be applied slowly and steadily without any impact load on the rope. Tests in which a breakage occurs adjacent to the grips ~~may are to~~ be rejected, and further samples may be taken for retests. If the applied breaking load is less than the minimum value given in the standards acceptable to CCS, the result will be considered to be unacceptable.

PART TWO NON-METALLIC MATERIALS

CHAPTER 2 PLASTICS MATERIALS

Section 2 RAW MATERIALS

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

- (1) density or relative density;
- (2) volume shrinkage after cure;
- (3) Barcol hardness;
- (4) tensile strength;
- (5) elongation at break;
- (6) water absorption (if required);
- (7) temperature of deflection.

Properties for Resin Castings Used for Lay-up

Table 2.2.2.5

Items	Standard	Unsaturated polyester/vinyl ester resin		epoxy resins
		Grade 1	Grade 2	
Tensile strength (N/mm ²)	ISO527-2	≥55	≥45	≥55
Elongation at break (%)	ISO527-2	≥2.5	≥1.5	≥2.5
Flexural modulus of elasticity (N/mm ²)	ISO178	≥2700	≥2700	≥2700
Flexural strength (N/mm ²)	ISO178	≥100	≥80	≥100
Heat deflection temperature (°C)	ISO75-2	≥70	≥60	≥75
Barcol hardness	ASTM D2583	≥35	≥35	≥35
Water absorption (mg)	ISO62	≤80	≤100	≤70

Note 1: [For unsaturated polyester resin and vinyl resin, test samples are to be solidified for 24 h under 50°C, and for epoxy resins, test samples are to be prepared in accordance with the requirements in ISO 3673-2 for preparation.](#)

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

Note 3: Gel coat resin and surface resin made of unsaturated polyester resin or vinyl resin are to meet the requirements for Grade 1.

2.2.7 Machinery chocking compounds (epoxy resin chocks)

2.2.7.1 The bicomponent thermosetting epoxy resin chocks for filling the space between the base of machinery and its foundation where the maintenance of accurate alignment is necessary are to be approved by CCS before use.

2.2.7.2 The casting manufacturer is to provide full details of construction, including design principles, operational methods and requirements, and installation procedure for information.

2.2.7.3 Cast samples of the resin chocks, for which approval is sought, are to achieve the minimum exotherm value as specified for use under practical conditions and be subject to the following approval tests.

2.2.7.4 The casting manufacturer is to determine the maximum temperature achieved by the reacting casting under conditions equivalent to those of intended use.

2.2.7.5 The following properties are to be determined on cured chock material:

- (1) Barcol hardness;
- (2) compressive strength and modulus of elasticity;
- (3) notched Izod impact strength;
- (4) curing linear shrinkage;
- (5) heat deflection temperature;
- (6) water absorption (immersed in artificial sea water and distilled water for 7 days);
- (7) oil absorption (immersed in diesel oil and lubricating oil for 7 days);
- (8) flammability.

~~2.2.7.6 The casting manufacturer is to have suitable test methods and data to demonstrate that the creep of epoxy resin chocks occurred at different temperatures will not affect their use under pressure for a sufficiently long period.~~

2.2.7.76 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 (not greater than 0.9 N/mm² for diesel engines with rated speed lower than 300 r/min), 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 2.2.7.76. For items not mentioned in the table, the results are to comply with limit values specified in the standards or by the manufacturer.

Requirements for Properties of Resin Chock Castings

Table 2.2.7.76

Compressive strength N/mm ²	Compressive modulus N/mm ²	Barcol hardness	Heat deflection temperature °C	Flammability	Water absorption ① %	Oil absorption ^① %
ASTM D695	ASTM D695	ASTM D2583	ISO 75-2	ASTM D635	ISO 62	ISO 62
≥120	≥5000	≥35	≥80	Self-extinguishing	≤0.9	≤0.9

Note: ① The size of test sample for water and oil absorption is 50 mm × 50 mm × 4 mm.

2.2.7.87 Where the castings are to be used for installation of stern tubes and stern bushes, the

measured tensile strength and modulus of elasticity in tension are to be provided, in addition to the requirements of 2.2.7.76. The tensile strength is not to be less than 34 MPa (ASTM D638).

2.2.7.8 Creep of the castings is to be measured according to and fulfill the following requirements:

(1) A 25 mm height × 20 mm diameter parallel faced cylinder is to be prepared and pre-loaded under a maximum static load that is intended to be approved, at ambient temperature for 16 hours. Its height is to be measured as the initial height H_0 .

(2) The temperature is to be increased at the rate of $8 \pm 1^\circ\text{C}$ per hour until the temperature of 80°C is reached.

(3) After reaching 80°C , the temperature (not more than $\pm 2^\circ\text{C}$) is to be maintained and loading is to be applied. The sample height is to be measured at intervals of 24 hours and the creep is to be calculated. A curve of creep (%) as the vertical axis against time (logarithm in minutes) as the horizontal axis was plotted (if it is a negative value, it means that the sample expanded). A report containing the above curve and test details are to be submitted to CCS.

(4) After 1000 hours, the height H_{1000} is to be measured and the maximum creep $((H_0 - H_{1000})/H_0 \times 100\%)$ is not to be greater than 0.2%, and at this time the creep curve should be basically stabilized without drastic changes.

CHAPTER 3 FIBER-REINFORCED PLASTIC HULL MATERIALS

Section 3 LAMINATING PROCEDURE

3.3.8 Laminate lay-up

3.3.8.1 The following principles are to be followed in laying up laminates:

(1) Reinforcements are to be arranged in a continuous manner, without any abrupt change in thickness, so as to maintain continuity of strength throughout the laminate.

(2) Laminating by using chopped strand mat (CSM) and BIAXIAL woven rovings (BIAXIAL) alternately is recommended.

(3) Adjacent pieces comprising a layer or ply of reinforcing material are in general to be overlapped along their edges and ends. The width of each overlap is to be not less than 50 mm. Where they are butted, butts in the same vertical plane are to be separated by not less than five passing plies, and tests are required to demonstrate continuity of strength.

(4) The position of the joints in the laminate (of either successive or lengthwise layers) is to be staggered at least by 150 mm.

(5) Changes in laminate thickness are to be made using a gradual taper, and the width of such transition area is to be at least ~~3020~~ times the difference in thickness. A gradual transition in fiber reinforcement is to be provided between bidirectional and unidirectional laminates. The arrangement of reinforcements in gradual transition zone should consider the transition direction of reinforcements at both ends of the connection.

3.3.9 Sandwich panel lay-up

3.3.9.12 Inserts in sandwich laminates, where required, are to be of a material capable of resisting crushing. Inserts are to be well bonded to the core material and to the laminate skins.

3.3.9.13 Scored core material is to be avoided. However, when necessary, only single cut core material is to be used in all external panels with the scored side placed upwards, to facilitate subsequent processing.

3.3.9.14 In all application procedures cured, excess bonding material is to be removed and the panel cleaned and primed (sealed) prior to the lamination of the final sandwich skin.

3.3.9.15 Where a sandwich laminate is transformed into a single skin laminate, the transition zone is to extend over at least 3 times the core thickness.

PART THREE WELDING

CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1.4 The welding of higher strength hull structural steels for large container ships with thicknesses of 50 mm to 100 mm and the specified minimum yield strength not less than 460 N/mm² is to comply with the requirements of CCS Guidelines for [Inspection Application](#) of Thick Higher Strength Steel Plates for Ships, in addition to the relevant requirements of this PART.

CHAPTER 2 WELDING CONSUMABLES

Section 2 MECHANICAL PROPERTIES OF WELDING CONSUMABLES

Mechanical Properties of Consumables for Welding Structural Steels

Table 2.2.2.3

Mechanical Properties of Consumables for Welding Structural Steels												Table 2.2.2.3					
Grade of welding consumables		1、2、3Y	1Y、2Y ①	2Y40 3Y40 4Y40 5Y40	3Y42 4Y42 5Y42	3Y46 4Y46 5Y46	3Y50 4Y50 5Y50	3Y55 4Y55 5Y55	3Y62 4Y62 5Y62	3Y69 4Y69 5Y69	3Y89 4Y89 5Y89	3Y96 4Y96 5Y96	1.5Ni	3.5Ni	5Ni	9Ni	
Deposited metal test	Yield strength ^⑦ <i>R_{eH}</i> (N/mm ²)	≥305	≥375	≥400	≥420	≥460	≥500	≥550	≥620	≥690	≥890	≥960	≥375				
	Tensile strength ^⑧ <i>R_m</i> (N/mm ²)	400-560	490-660	510-690	520-680	540-720	590-770	640-820	700-890	770-940	940-1100	980-1150	≥460	≥420	≥500	≥600	
	Elongation A(%)	≥22			≥20		≥18			≥17	≥14	≥13	≥22	≥25			
	Charpy V-notch impact test	②												-80	-100	-120	-196
	Average impact energy ^⑥ (J)	≥47 ^③			≥47		≥50	≥55	≥62	≥69	≥69	≥69	≥69 ^④				
Butt weld test	Transverse tensile strength (N/mm ²)	≥400	≥490	≥510	≥520	≥540	≥590	≥640	≥700	≥770	940	980	≥490	≥450	≥540	≥640	
	Charpy V-notch impact test	②												-80	-100	-120	-196
	Average impact energy ^⑥ (J)	≥47 ^④			≥47		≥50	≥55	≥62	≥69	≥69	≥69	≥69 ^④				
	Bend test	After testing, the test specimens are not to reveal any open defects in any direction greater than 3 mm. ^⑤															

Notes: ① Manual arc welding electrodes are to comply with Grade 2Y and above.

② The temperature of impact test for welding consumables of Grade 1 and Grade 1Y is to be 20℃; for those of Grades 2, 2Y, 2Y40 to be 0℃;

for those of Grades 3, 3Y, 3Y40, 3Y42, 3Y46, 3Y50, 3Y55, 3Y62, 3Y69, 3Y89, 3Y96 to be -20℃;

for those of Grades 4Y, 4Y40, 4Y42, 4Y46, 4Y50, 4Y55, 4Y62, 4Y69, 4Y89, 4Y96 to be -40℃;

for those of Grades 5Y40, 5Y42, 5Y46, 5Y50, 5Y55, 5Y62, 5Y69, 5Y89, 5Y96 to be -60℃.

Acceptance values of impact tests for welding consumables of Grades 5Y89, 5Y96 are to be specially considered by CCS.

③ The average impact energy of deposited metal test of submerged arc automatic welding is not to be less than 34 J for welding consumables with $R_{eH} < 400$ N/mm²; not to be less than 39 J for those with $R_{eH} \geq 400$ N/mm².

④ The average impact energy of butt joints of vertical welding and submerged arc automatic welding is not to be less than 34 J for welding consumables with $R_{eH} < 400$ N/mm²; not to be less than 39 J for those with $R_{eH} \geq 400$ N/mm².

⑤ Except for 5Ni and 9Ni steel specimens to be bend tested with a former of diameter four times the plate thickness, the diameter of former is to comply with the requirements of 1.2.4.2 of this PART.

⑥ Energy values from individual impact test specimens are not to be less than 70% of the specified values.

⑦ In case of no marked yield stress, the proof stress $R_{p0.2}$ is to be reported.

⑧ Where the tensile strength exceeds the specified maximum value, special consideration is to be given by CCS.

Section 9 WELDING CONSUMABLES FOR ALUMINUM ALLOYS

2.9.2.3 For rod-gas combinations used in tungsten inert gas arc welding (TIG) and/or plasma arc welding, the letter “R” is to be added before the grade mark, e.g. “RB”.

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.

CHAPTER 3 APPROVAL OF WELDING PROCEDURES

Section 1 GENERAL PROVISIONS

3.1.4.3 The application of a welding procedure specification to steel is specified as follows:

(1) For each strength level, welding procedures are considered applicable to the same and lower toughness grades as that tested.

(2) For each toughness grade where the minimum value of the specified yield strength of steel is not more than 390 N/mm², welding procedures are considered applicable to the same and two lower strength levels as that tested ([H27 steel is not considered as a separate grade here. For example, the welding procedure for AH36 steel is applicable to AH32, AH27 and A steel.](#) For high strength quenched and tempered steel, welding procedures are considered applicable to the same and one lower strength level as that tested.

Section 2 WELDING PROCEDURE APPROVAL TESTS FOR BUTT WELDS

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, AH27 , AH32, AH36, AH40	B, D, DH27 , DH32, DH36, DH40, AH420, AH460, AH500, AH550, AH620, AH690, AH890, AH960	E, EH27 , EH32, EH36, EH40, DH420, DH460, DH500, DH550, DH620, DH690, DH890, DH960	FH27 , FH32, FH36, FH40, EH420, EH460, EH500, EH550, EH620, EH690, EH890, EH960	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	AH27 , H27 , EH27 , FH27	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.

3.2.7 Additional requirements for welding procedures approval tests of stainless steels

3.2.7.2 For [duplex stainless steel and lean](#) duplex stainless steel, in addition to the relevant requirements of 3.2.4.1 and 3.2.5 above, the following requirements are to be complied with:

- (1) the center of the weld, fusion line and heat affected zone 2 mm from the fusion line are to be subject to the impact test individually (test temperature is -20°C). The impact energy is not to be less than 27 J;
- (2) the result of the hardness test is not to be greater than HV420;
- (3) the pitting corrosion test of welds is to be carried out in accordance with the requirements of Section 9, Chapter 2, PART ONE of the Rules (except connection to other stainless steels or carbon steels);
- (4) micro examination of welds and heat affected zones is to exhibit no grain boundary carbides and intermetallic precipitates;
- (5) the ferritic content of the welds and the heat affected zone of the final and root runs are measured separately. The content is to be within the range from 30% to 70%.

CHAPTER 4 QUALIFICATION TESTS OF WELDERS

Section 2 QUALIFICATION TESTS AND EVALUATION OF WELDERS

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

- (1) Hull structural steels specified in Sections 2 and 3, Chapter 3, PART ONE of the Rules;
- (2) Hull structural forged steels specified in Section 2, Chapter 5, PART ONE of the Rules;
- (3) Hull structural cast steels specified in Section 2, Chapter 6, PART ONE of the Rules;
- (4) Hull structural steels with specified minimum yield point 460 N/mm² specified in CCS Guidelines for [Inspection Application](#) of Thick Higher Strength Steel Plates for Ships.

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

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

Section 3 SCOPE OF APPLICATION OF WELDER'S QUALIFICATION

4.3.4.1 Steels are grouped in Table 4.3.4.1. The welding of any one metal in this group covers qualification of the welder or welding operator for the welding of all other metals within this group.

Steel Groups

Table 4.3.4.1

Material group	Steel type
W01 ^①	Carbon steel/carbon-manganese steel and low-alloy higher tensile steel with yield strength $R_{eH} \leq 390$ N/mm ²
W02	CrMo steel and creep-resistant CrMoV steel
W03	Higher tensile steel with yield strength $R_{eH} > 390$ N/mm ² , and nickel steel with Ni content < 5% ^②
W04	Ferritic or martensitic stainless steel with Cr content between 12% and 20%
W05	Nickel steel for low temperature service with Ni content $\geq 5\%$
W11	Austenitic, duplex stainless steel or lean duplex stainless steel

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

② Except for those included in W01.

CHAPTER 5 WELDING OF HULL STRUCTURES

Section 1 GENERAL PROVISIONS

5.1.3.4 When line heating or spot heating is used for curve forming or smoothing treatment, the surface heating temperature is to meet the requirements of Table [5.1.4.4 5.1.3.4](#).

Maximum Heating Temperature on Steel Surface for Line Heating or Spot Heating

Table 5.1.3.4

Item	Standard
Conventional process AH27-EH27 , AH32-EH32, AH36-EH36	Water cooling just after heating
	Air cooling after heating
	Under 650°C
	Under 900°C

TMCP type AH36-EH36 ($C_{eq} > 0.38\%$)	Air cooling and subsequent water cooling after heating	Under 900°C (starting temperature of water cooling to be under 500°C)
TMCP type AH27-DH27 , AH32-DH32, AH36-DH36 ($C_{eq} \leq 0.38\%$)	Water cooling just after heating or air cooling	Under 1000°C
TMCP type EH27 , EH32, EH36 ($C_{eq} \leq 0.38\%$)	Water cooling just after heating or air cooling	Under 900°C

5.1.4 Selection of welding consumables

5.1.4.1 Welding consumables used for hull structures are to comply with the requirements of Chapter 2 of this PART. The grade of welding consumables selected is to be suitable for the grade of hull structural steel, and is to comply with the requirements of Table 5.1.4.1.

Selection of Welding Consumables

Table 5.1.4.1

Hull structural steel grade Grade of welding consumables	A	B	D	E	AH27 AH32 AH36	DH27 DH32 DH36	EH27 EH32 EH36	FH27 FH32 FH36	AH40	DH40	EH40	FH40
1	×											
2	×	×	×									
3	×	×	×	×								
1Y	×				×②							
2Y	×	×	×		×	×						
3Y	×	×	×	×	×	×	×					
4Y	×	×	×	×	×	×	×	×				
2Y40	①	①	①		×	×			×	×		
3Y40	①	①	①	①	×	×	×		×	×	×	
4Y40	①	①	①	①	×	×	×	×	×	×	×	×
5 Y40	①	①	①	①	×	×	×	×	×	×	×	×

Notes: “×” means applicable.

- ① When joining structural steels of normal strength, it is not recommended to use a much higher grade of welding consumable.
- ② When using Grade 1Y welding consumables, the material thickness is not to exceed 25 mm.

Section 2 WELDING OF HULL STRUCTURAL MEMBERS

5.2.3 Welding of higher tensile steels

5.2.3.1 For the welding of higher tensile steels, low hydrogen high strength welding consumables suitable for the parent plate and approved by CCS are to be used. During welding, preheating is to be made, and heat input and interpass temperatures are to be controlled.

5.2.3.2 Where higher tensile steel is used for the hull structure, welds are to have a smooth profile without excessive buildup.

5.2.3.3 Where hull structural members, such as stems, stern frames, rudder blades, are of welded higher tensile steel plates, these members are to be annealed so as to relieve the residual stress on completion of the welding. The annealing temperature is to be higher than the critical temperature, and the weldment is then to be cooled slowly.

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).

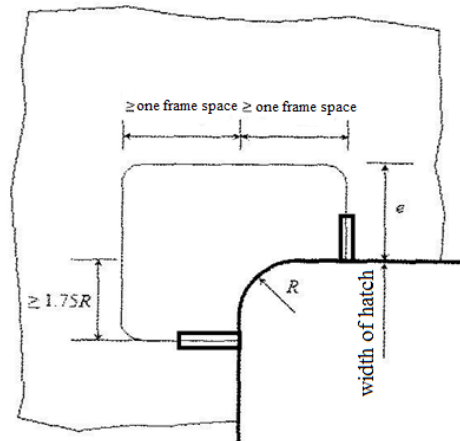


Figure 5.3.2.6(3)

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

- a. Welds of steel castings and steel forgings as well as welds welded under stress or low temperature are to be subject to 100% surface crack examination;
- b. Welds of essential positions with plate thickness of 30 mm or above (e.g. welds on stern frames, welded mast and bulkhead stool, etc.) are to be subject to 100% surface crack examination;
- c. Welds in high stress areas are to be subject to 100% surface crack examination.
- d. Other welds with edge preparation thickness at 30 mm or above are to be subject to 20% surface crack examination as a minimum.

CHAPTER 6 WELDING OF OFFSHORE STRUCTURES

Section 3 INSPECTION OF WELDS

6.3.2 Supplementary requirements for fixed offshore structures

6.3.2.1 Visual inspection

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

- ① the reinforcement of butt welds is to comply with the relevant criteria and not to exceed 3 mm;
- ② for fillet welds, the length difference between two legs is not to exceed 2 mm and buildup R is not to exceed the value calculated by the following formula:

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

where: K – leg length of fillet welds;

- ③ weld dimensions of pipe joints are to be as shown in Figure 6.3.2.1(1)①, ② and Table 6.3.2.1(1). The profile after grinding is to comply with the relevant requirements of the design and construction;

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

CHAPTER 7 WELDING OF PRESSURE SHELLS

Section 2 PRODUCTION WELDING TESTS OF PRESSURE SHELLS

7.2.3.1 The test specimens for various classes of pressure shells are to be taken as required by Figure 7.2.3.1 and Table 7.2.3.1.

Specimens for Classes of Pressure Shells		Table 7.2.3.1	
No.	Specimen	Pressure shell	
		Class I	Class II
1	Deposited metal longitudinal tensile	Required	Required
2	Face bend ^①	Required	Required
3	Root bend ^①	Required	Required
4	Butt weld transverse tensile	Required	Required
5	Macro examination	Required	Required
6, 7, 8	Impact test for center of the weld ^②	Required	

Notes: ① Where a test plate is greater not less than 20mm12mm in thickness, a side bend test specimen may be substituted for the face or root bend specimen.

- ② An additional set of 3 impact specimens with the notch located on the fusion line is to be tested in the following conditions:
- pressure shells of diving systems and submersibles;
 - all pressure shells with design temperature at 0°C and below;
 - pressure shells made of alloy steels (excluding austenitic stainless steel).

CHAPTER 11 WELDING AND RIVETING OF NON-FERROUS MATERIALS

Section 3 WELDING OF TITANIUM AND TITANIUM ALLOYS

11.3.5 Welding

11.3.5.1 The usual welding methods for titanium alloy components include argon-shielded tungsten arc welding, metal argon-shielded arc welding and plasma welding.

11.3.5.2 Titanium cannot be connected by penetration welding to many metals such as steel. Mixing with steel and other metals is prohibited in penetration welding of titanium.

11.3.5.3 The parameters of the welding procedure is to be selected to ensure adequate penetration depth and good protection to avoid defects, and welding rules requiring small energy heat input are to be adopted so far as practicable.