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RULES FOR MATERIALS AND WELDING

Amendments

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PART ONE METALLIC MATERIALS

CHAPTER 2 MATERIAL TESTS

Section 7 INTERCRYSTALLINE CORROSION TESTS OF STAINLESS STEEL

2.7.2 Preparation of test specimens

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

For small-diameter tubes with external diameter not greater than 56 mm, test pieces may be cut directly as the specimen for flattening test.

2.7.3 Testing

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

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

(2) ~~mixed with~~ add 100 ml sulphuric acid (relative density 1.84 g/ml) slowly into the solution mentioned in (1);

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

2.7.3.3 Cleaned specimens are to be heated to a temperature of 700 ±10℃ for 30 min, followed by rapid cooling in water. They are then to be positioned on the bed of copper turnings in the test vessel. Add the corroding media solution to immerse the entire specimen. Heat the test vessel so that the specimen is immersed in the boiling corroding media for not less than 16 h (but not more than 24 h) ~~and immersed for 15 to 24 h in the boiling solution~~. Precautions are to be taken to prevent concentration of the solution by evaporation. Where multiple specimens are positioned in the vessel, the ratio between total volume of the solution and total surface area of the specimens is not to be less than 10 ml/cm^2, and there is to be no contact between specimens.

2.7.3.4 After immersion, each test specimen is to be bent under the conditions specified in Table 2.7.3.4~~,~~ at ambient temperature~~, to 90° over a former with a diameter equal to twice the diameter or thickness of the specimen~~.

Bending Radius and Angle of Test Specimens of Intercrystalline Corrosion Tests Table 2.7.3.4

Product type	Radius of former	Bending angle
Rolled product	Diameter or thickness of the specimen	90°
Forged product	Twice the thickness of the specimen	90°

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

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

CHAPTER 3 STEEL PLATES, FLAT BARS AND SECTIONS

Section 2 NORMAL STRENGTH HULL STRUCTURAL STEELS

3.2.1.1 Normal strength hull structural steel is subdivided into four grades as A, B, D and E. The requirements of this Section apply to steel plates and wide flats not more than 1500 mm in thickness and sections and bars not more than 50 mm in thickness.

Condition of Supply for Normal Strength Hull Structural Steel **Table 3.2.3.1**

Grade	Deoxidation	Products	Condition of supply①②				
			Thickness t (mm)				
			$t \le 12.5$	$12.5 < t \le 25$	$25 < t \le 35$	$35 < t \le 50$	$50 < t \le 1500$
A	Rimmed steel	Sections	A(-)	Not applicable			
	For $t \le 50$ mm, any method except rimmed steel; for $t > 50$, killed	Plates	A(-)				N(-), TM(-), CR(50), AR*(50)
		Sections	A(-)				Not applicable
B	For $t \le 50$ mm, any method except rimmed steel; for $t > 50$, killed	Plates	A(-)		A(50)		N(50), TM(50), CR(25), AR*(25)
		Sections	A(-)		A(50)		Not applicable
D	Killed	Plates, Sections	A(50)		Not applicable		
	Killed and fine grain treated	Plates	A(50)			N(50), CR(50), TM(50)	N(50), TM(50), CR(25)
		Sections	A(50)			N(50), CR(50), TM(50), AR*(25)	Not applicable
E	Killed and fine grain treated	Plates	N(each piece), TM(each piece)				
		Sections	N(25), TM(25), AR*(15), CR*(15)				Not applicable

Notes: ① Condition of supply: A: any; N: normalized; CR: controlled; TM (TMCP): thermo-mechanical controlled process; 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), (-) means impact tests are not required. One set of three Charpy V-notch impact test specimens is to be taken from each batch weight.

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

Mechanical Properties of Normal Strength Hull Structural Steel **Table 3.2.4.3**

Grade	Yield strength R_{eH} min. (N/mm^2)	Tensile strength R_m (N/mm^2)	Elongation A_5 min. (%)	Charpy V-notch impact test						
				Test temp. (℃)	Average impact energy min. (J)					
					Thickness t (mm)					
					$t \le 50$		$50 < t \le 70$		$70 < t \le 1500$	
					Long.②	Trans.②	Long.	Trans.	Long.	Trans.
A	235	400 – 520①	22	20	–	–	34④	24④	41④	27④
B				0	27③	20③				
D				-20						
E				-40						

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

② Generally for product thickness not exceeding 50 mm, impact tests need only be made in the longitudinal direction,

except when required by the purchaser or CCS; however, satisfactory transverse test results for plates and wide flats are to be guaranteed by the manufacturer.

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

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

⑤ Transverse impact tests are generally not required for sections.

Section 3 HIGHER STRENGTH HULL STRUCTURAL STEELS

3.3.1 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 AH32, DH32, EH32, FH32, AH36, DH36, EH36, FH36, AH40, DH40, EH40 and FH40 steel plates and wide flats of thickness not exceeding 1500 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		AH32, AH36, AH40, DH32, DH36, DH40, EH32, EH36, EH40	FH32, FH36, FH40
Chemical composition (%)⑤⑥	C	≤ 0.18	≤ 0.16
	Mn	0.90 ~ 1.60①	0.90 ~ 1.60
	Si	≤ 0.50	≤ 0.50
	S	≤ 0.035	≤ 0.025
	P	≤ 0.035	≤ 0.025
	Al(acid soluble)	≥ 0.015②③	≥ 0.015②③
	Nb④	0.02 ~ 0.05③	0.02 ~ 0.05③
	V④	0.05 ~ 0.10③	0.05 ~ 0.10③
	Ti④	≤ 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)

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

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

(2) If needed, the cold cracking susceptibility P_{CM} may be used instead of the carbon equivalent for evaluating weldability, in which case the following formula is to be used:

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

The P_{CM} value so obtained is to comply with an appropriate recognized standard.

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

Table 3.3.2.3(1)

Grade	Carbon equivalent① C_{eq} (%)		
	thickness t (mm)		
	$t \leq 50$	$50 < t \leq 100$	$100 < t \leq 150$
AH32, DH32, EH32, FH32	≤ 0.36	≤ 0.38	≤ 0.40
AH36, DH36, EH36, FH36	≤ 0.38	≤ 0.40	≤ 0.42
AH40, DH40, EH40, FH40	≤ 0.40	≤ 0.42	≤ 0.45

Note: 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 Heat treatment

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)					
			$t \leq 12.5$	$12.5 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 35$	$35 < t \leq 50$	$50 < t \leq 150$
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
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
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
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 ~~(thermo-mechanical controlled processing)~~; 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 Mechanical properties

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 test①					
				Test temp. (℃)	Average energy min. (J)				
					Thickness t (mm)				
					$t \le 50$		$50 < t \le 70$		$70 < t \le 150$
					Long.	Trans.	Long.	Trans.	Long.	Trans.
AH32	315	440 ~ 570	22	0	31②	22②	38	26	46	31
DH32				-20						
EH32				-40						
FH32				-60						
AH36	355	490 ~ 630	21	0	34②	24②	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 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.

Minimum Elongation of Full-Thickness Flat Test Specimens Table 3.3.4.4

Thickness t (mm)	Grade	$t \le 5$	$5 < t \le 10$	$10 < t \le 15$	$15 < t \le 20$	$20 < t \le 25$	$25 < t \le 30$	$30 < t \le 40$	$40 < t \le 50$
Elongation A (%)	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 4 HIGH STRENGTH QUENCHED AND TEMPERED STEELS FOR WELDED STRUCTURES

Minimum Elongation of Full-Thickness Flat Test Specimens **Table 3.4.4.5**

Thickness t (mm)	Grade	$t \le 10$	$10 < t \le 15$	$15 < t \le 20$	$20 < t \le 25$	$25 < t \le 40$	$40 < t \le 50$	$50 < t \le 70$
Elongation A (%)	420	11	13	14	15	16	17	18
	460	11	12	13	14	15	16	17
	500	10	11	12	13	14	15	16
	550	10	11	12	13	14	15	16
	620	9	11	12	12	13	14	15
	690	9	10	11	11	12	13	14

Section 7 STEELS FOR LOW TEMPERATURE SERVICE

Chemical Composition of nickel alloy steel **Table 3.7.2.3**

Grade	Chemical composition (%)						
	C	Mn	Si	P	S	Ni	Other elements
1.5Ni	≤ 0.14	0.30~1.50	0.10~0.35	≤ 0.025	≤ 0.02	1.30~1.70	Cr ≤ 0.25 Mo ≤ 0.08 Cu ≤ 0.35 Cr+Mo+Cu ≤ 0.60 Al(acid soluble) ≥ 0.015
2.25Ni	≤ 0.14	≤ 0.70	≤ 0.30	≤ 0.025	≤ 0.025	2.10~2.50	
3.5Ni	≤ 0.12	0.30~0.80	0.10~0.35	≤ 0.025	≤ 0.02	3.20~3.80	
5Ni	≤ 0.12	0.30~0.90	0.10~0.35	≤ 0.025	≤ 0.02	4.70~5.30	
9Ni	≤ 0.10	0.30~0.90	0.10~0.35	≤ 0.025	≤ 0.02	8.5~10.0	

Note: ① Nitrogen content is not to exceed 0.009% (or 0.012% where aluminium is present).

Conditions of supply and mechanical properties of carbon-manganese steel① **Table 3.7.3.1**

Grade	Condition of supply②	Yield strength R_{eH} min. (N/mm^2)	Tensile strength R_m (N/mm^2)	Elongation A_5 min. (%)	Charpy V-notch impact tests				Design Temp. min. (℃)
					Material thickness t (mm)	Test Temp. T (℃)	Average energy of test specimens, min. (J)		
							Long.	Trans.	
CL-I-2	Normalized or quenched and tempered	315	440-570	22	$t \le 25$ $25 < t \le 30$ $30 < t \le 35$ $35 < t \le 40$	-20 -25 -30 -35	41	27	-15
CL-II-2		315	440-570	22	$t \le 25$ $25 < t \le 30$ $30 < t \le 35$ $35 < t \le 40$	-40 -45 -50 -55	41	27	-35
CL-III-2		315	440-570	22	$t \le 25$ $25 < t \le 30$ $30 < t \le 35$ $35 < t \le 40$	-60 -65 -70 -75	41	27	-55
CL-I-3		355	490-630	21	$t \le 25$ $25 < t \le 30$ $30 < t \le 35$ $35 < t \le 40$	-20 -25 -30 -35	41	27	-15
CL-II-3		355	490-630	21	$t \le 25$ $25 < t \le 30$ $30 < t \le 35$ $35 < t \le 40$	-40 -45 -50 -55	41	27	-35
CL-III-3		355	490-630	21	$t \le 25$ $25 < t \le 30$ $30 < t \le 35$ $35 < t \le 40$	-60 -65 -70 -75	41	27	-55

Grade	Condition of supply②	Yield strength R_{eH} min. (N/mm^2)	Tensile strength R_m (N/mm^2)	Elongation A_5 min. (%)	Charpy V-notch impact tests				Design Temp. min. (℃)
					Material thickness t (mm)	Test Temp. T (℃)	Average energy of test specimens, min. (J)		
							Long.	Trans.	
CL-I-4		390	510-660	20	$t\leq25$ $25<t\leq30$ $30<t\leq35$ $35<t\leq40$	-20 -25 -30 -35	41	27	-15
CL-II-4		390	510-660	20	$t\leq25$ $25<t\leq30$ $30<t\leq35$ $35<t\leq40$	-40 -45 -50 -55	41	27	-35
CL-III-4		390	510-660	20	$t\leq25$ $25<t\leq30$ $30<t\leq35$ $35<t\leq40$	-60 -65 -70 -75	41	27	-55

① 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.
② Controlled rolling process or TMCP may replace normalized or quenched and tempered.
③ In the table, the transverse values of impact tests apply to plates and the longitudinal values to sections.

Section 8 AUSTENITIC AND DUPLEX STAINLESS STEELS

3.8.3 Chemical composition

3.8.3.1 The chemical composition of ladle samples of austenitic stainless steels is to comply with the following requirements given in Table 3.8.3.1.

Chemical Composition of Austenitic Stainless Steels **Table 3.8.3.1**

Grade	Uniform numbercode	Chemical composition (%)									
		C	Si	Mn	P	S	Cr	Ni	Mo	N	Other elements
06Cr19Ni10①	S30408	≤0.08	≤1.0	≤2.0	≤0.045	≤0.03	18.0~20.0	8.0~11.0	—	—	
022Cr19Ni10	S30403	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	18.0~20.0	8.0~12.0	–	–	
022Cr19Ni10N	S30453	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	18.0~20.0	8.0~11.0	–	0.10~0.16	
06Cr17Ni12Mo2①	S31608	≤0.08	≤1.0	≤2.0	≤0.045	≤0.03	16.0~18.0	10.0~14.0	2.0~3.0	—	
022Cr17Ni12Mo2	S31603	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	16.0~18.0	10.0~14.0	2.0~3.0	–	
022Cr17Ni12Mo2N	S31653	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	16.0~18.0	10.0~13.0	2.0~3.0	0.10~0.16	
06Cr19Ni13Mo3①	S31708	≤0.08	≤1.0	≤2.0	≤0.045	≤0.03	18.0~20.0	11.0~15.0	3.0~4.0	—	
022Cr19Ni13Mo3	S31703	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	18.0~20.0	11.0~15.0	3.0~4.0	–	
022Cr19Ni13Mo4N	S31753	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	18.0~20.0	11.0~15.0	3.0~4.0	0.10~0.22	
06Cr18Ni11Nb	S34778	≤0.08	≤1.0	≤2.0	≤0.045	≤0.03	17.0~19.0	9.0~12.0	–	–	10C≤Nb≤1.10

Note: ① Generally not used as vessel members having direct contact with corrosive chemicals.

3.8.5 Mechanical properties

3.8.5.3 The mechanical properties of austenitic stainless steels are to comply with the following requirements given in Table 3.8.5.3.

Mechanical Properties of Austenitic Stainless Steels **Table 3.8.5.3**

Grade	Proof strength $R_{p0.2}$ ① min. (N/mm^2)	Proof strength $R_{p1.0}$ ① min. (N/mm^2)	Tensile strength R_m ② min. (N/mm^2)	Elongation A_5 min. (%)
06Cr19Ni10	205	245	515	40
022Cr19Ni10	175	215	480	40
022Cr19Ni10N	245	285	550	40
06Cr17Ni12Mo2	205	245	515	40
022Cr17Ni12Mo2	175	215	480	40
022Cr17Ni12Mo2N	245	285	550	40
06Cr19Ni13Mo3	205	245	515	40
022Cr19Ni13Mo3	205	245	520	40
022Cr19Ni13Mo4N	275	315	570	40
06Cr18Ni11Nb	205	245	520	40

Notes: ① Proof strength $R_{p0.2}$ is normally to be determined. Where specified otherwise in the contract, the proof strength $R_{p1.0}$ may be set for delivery.

② The upper limit of tensile strength of austenitic stainless steels is not to exceed any value in the Table plus 200 N/mm^2.

3.8.6 Intercrystalline corrosion tests

3.8.6.1 When stainless steels are used for certain environment, such as tanks or storage tanks containing corrosive chemicals, ~~intercrystalline corrosion tests are required for stainless steel,~~ 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.

CHAPTER 4 STEEL PIPES AND TUBES

Section 5 FERRITIC STEEL PRESSURE PIPES FOR LOW TEMPERATURE SERVICE

4.5.1 Application

4.5.1.1 The requirements of this Section apply to carbon, carbon-manganese and nickel alloy pipes suitable for use in the piping arrangements for cargo tanks and processing equipment of liquefied gas carriers where the design temperature is ~~less than~~ 0℃ to -165℃.

4.5.2 Manufacture and chemical composition

4.5.2.1 The pipes are to be manufactured in accordance with the methods given in Table 4.5.2.1.

4.5.2.2 Pipes using longitudinal welding and spiral welding are to comply with the relevant requirements of Section 3 of this Chapter on welded pressure pipes in addition to satisfying the requirements of this Section.

Method of Manufacture of Ferritic Steel Pressure Pipes for Low Temperature Service

Table 4.5.2.1

Steel type	Method of manufacture
Carbon and carbon-manganese	Hot or cold finished seamless or electric resistance or induction welded
Nickel alloy	Hot or cold finished seamless

4.5.2.~~32~~ The method of deoxidation and the chemical composition of ladle samples are to comply with the appropriate requirements given in Table 4.5.2.~~32~~.

Deoxidation and Chemical Composition of Ferritic Steel Pressure Pipes for Low Temperature Service

Table 4.5.2.~~32~~

Steel type	Grade (N/mm^2)	Deoxidation	Chemical composition (%)							
			C	Si	Mn	P	S	Ni	Residual elements	Other elements①②
Carbon	360	Fully killed grain practice	≤0.17	0.10~0.35	0.40~1.00	~~≤0.045~~0.03	~~≤0.045~~0.025		Cr≤0.25; Cu≤0.30 Mo≤0.10; Ni≤0.30 Total≤0.70	Al≥0.015 (Acid soluble)
Carbon-manganese	410 460		≤0.20	0.10~0.35	0.60~1.40	~~≤0.045~~0.03	~~≤0.045~~0.025			Al≥0.015 (Acid soluble)
3.5Ni	440	Fully killed	≤0.15	0.10~0.35	0.30~0.90	≤0.040	≤0.040	3.25~3.75	0≤0.25 Cu≤0.30 Mo≤0.10 Total≤0.60	–
9Ni	690		≤0.13	0.10~0.35	0.30~0.90	≤0.040	≤0.040	8.50~9.50		–

Notes: ① Al may be wholly or partly replaced by other fine grain elements

② Where a minimum Al of 0.015% is specified, the determination of the total aluminum is acceptable provided that the result is not less than ~~0.018%~~0.020%.

4.5.3 Heat treatment

4.5.3.1 The heat treatment of the pipes is to comply with the requirements given in Table 4.5.3.1.

Heat Treatment of Ferritic Steel Pressure Pipes for Low Temperature Service Table 4.5.3.1

Steel type	~~Method of manufacture~~ Delivery condition
Carbon or carbon-manganese④	Normalized or agreed heat treatment~~normalized and tempered~~

3.5Ni	Normalized or normalized and tempered or quenched and tempered
9Ni	Double normalized and tempered or quenched and tempered

~~Note: ① Carbon or carbon-manganese steels may be supplied in the hot finished condition.~~

4.5.4 Mechanical and technical properties

4.5.4.1 All pipes are to be presented for tensile and flattening or bend tests in batches as defined in 4.1.6.2 and 4.1.6.3 of this Chapter.

Where the wall thickness allows for standard specimen the width of which is 5 mm or greater to be taken, an impact test is to be carried out at the test temperatures specified in Table 4.5.4.2 for each pipe to be tested. The impact tests are to be carried out for one set of three Charpy V-notch test specimens cut in the longitudinal direction and with the notch perpendicular to the original surface of the pipe. The dimensions of the test specimens and the testing methods are to be in accordance with the relevant requirements of Section 3, Chapter 2 of this PART.

4.5.4.2 The results of all tests are to comply with the appropriate values given in Table 4.5.4.2.

Mechanical and Technical Properties of Ferritic Steel Pressure Pipes for Low Temperature Service

Table 4.5.4.2

Steel type	Grade (N/mm^2)	Tensile strength① R_m min. (N/mm^2)	Yield strength① R_{eH} min. (N/mm^2)	Elongation A_5 min. (%)	Flattening test constant C	Bend test diameter of former (mm)	Charpy V-notch impact test	
							Test temp (℃)	Average energy② min.(J)
Carbon	360	360	210	24	0.10	$4t$② (~~t being thickness~~)	③	27
Carbon-manganese	410	410	235	22	0.08	$4t$		27
	460	460	260	21	0.07			
3.5Ni	440	440	245	16	0.08	$4t$	~~-100~~ -95	34
9Ni	~~490~~690	~~490~~690	~~310~~510	15	0.08	$4t$	-196	41

Notes:① For carbon and carbon-manganese steels, the tensile strength range for all grades in the Table is 120 N/mm^2. For nickel alloy steels, the tensile strength range for all grades in the Table is 150 N/mm^2.

② t is thickness of the specimen~~For energy values for impact test specimens, one individual value may be less than the required average value provided that it is not less than 70% of this value~~.

③ The test temperature is to be 5℃ below the design temperature or -20℃, whichever is the lower.

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

4.6.1 Application

4.6.1.1 The requirements of this Section apply to austenitic stainless steel pressure pipes ~~suitable for use in the piping arrangements for cargo tanks and processing equipment of liquefied gas carriers and bulk chemical tankers~~ where the design temperature is not less than -165℃ and austenitic stainless steel and austenitic/ferritic duplex stainless steel pressure pipes used in corrosive environment.

4.6.1.3 Austenitic/ferritic duplex stainless steels are generally used where the design temperature is between 0℃ to 300℃.

4.6.2 Manufacture and chemical composition

4.6.2.2 The chemical composition of the ladle samples is to comply with the appropriate requirements of

Table 4.6.2.2(1) or 4.6.2.2(2).

Chemical Composition of Austenitic Stainless Steel Pressure Pipes Table 4.6.2.2(1)

Grade	Uniform number code	Chemical composition (%)									
		C	Si	Mn	P	S	Cr	Ni	Mo	N	Other elements
06Cr19Ni10	S30408	≤0.08	≤1.00	≤2.00	≤0.045	≤0.030	18.0~20.0	8.0~11.0	—	—	—
022Cr19Ni10	S30403	≤0.03	≤1.00	≤2.00	≤0.045	≤0.030	18.0~20.0	8.0~12.0	—	—	—
06Cr17Ni12Mo2	S31608	≤0.08	≤1.00	≤2.00	≤0.045	≤0.030	16.0~18.0	10.0~14.0	2.0~3.0	—	—
022Cr17Ni12Mo2	S31603	≤0.03	≤1.00	≤2.00	≤0.045	≤0.030	16.0~18.0	10.0~14.0	2.0~3.0	—	—
06Cr19Ni13Mo3	S31708	≤0.08	≤1.00	≤2.00	≤0.045	≤0.030	18.0~20.0	11.0~15.0	3.0~4.0	—	—
022Cr19Ni13Mo3	S31703	≤0.03	≤1.00	≤2.00	≤0.045	≤0.030	18.0~20.0	11.0~15.0	3.0~4.0	—	—
06Cr18Ni11~~0~~Ti	S32168	≤0.08	≤1.00	≤2.00	≤0.045	≤0.030	17.0~19.0	9.0~12.0	—	—	5C≤Ti≤0.80
06Cr18Ni11Nb	S34778	≤0.08	≤1.00	≤2.00	≤0.045	≤0.030	17.0~19.0	9.0~12.0	—	—	10C≤Nb≤1.10

Chemical Composition of Duplex Stainless Steel Table 4.6.2.2(2)

Grade	Uniform number code	Chemical composition (%)									
		C	Mn	Si	P	S	Cr	Ni	Mo	N	Other elements
022Cr22Ni5Mo3N	S22253	≤0.03	≤2.0	≤1.0	≤0.030	≤0.020	21.0~23.0	4.5~6.5	2.5~3.5	0.08~0.20	
022Cr23Ni5Mo3N	S22053	≤0.03	≤2.0	≤1.0	≤0.030	≤0.020	22.0~23.0	4.5~6.5	3.0~3.5	0.14~0.20	
03Cr25Ni6Mo3Cu2N	S25554	≤0.04	≤1.5	≤1.0	≤0.035	≤0.030	24.0~27.0	4.5~6.5	2.9~3.9	0.10~0.25	1.5≤Cu≤2.5
022Cr25Ni7Mo4N	S25073	≤0.03	≤1.2	≤0.8	≤0.035	≤0.020	24.0~26.0	6.0~8.0	3.0~5.0	0.24~0.32	Cu≤0.50

4.6.4 Mechanical and technical properties

4.6.4.1 All austenitic stainless steel or austenitic/ferritic duplex stainless steel pressure pipes are to be presented in batches as defined in 4.1.6 of this Chapter for Class I and II piping systems. Each pipe selected for test is to be subjected to tensile and flattening or bend tests. The results of all tests are to comply with the appropriate requirements given in Table 4.6.4.1(1) or 4.6.4.1(2).

Mechanical and Technical Properties of Austenitic Stainless Steel Pressure Pipes Table 4.6.4.1(1)

Grade	Uniform number code	Proof strength $R_{p0.2}$ min. (N/mm^2)	Proof strength $R_{p1.0}$ min. (N/mm^2)	Tensile strength R_m (N/mm^2)	Elongation A_5 min. (%)	Flattening test constant C	Bend test diameter of former D
06Cr19Ni10	S30408	205	245	520~720	35	0.09	3t (t being thickness)
022Cr19Ni10	S30403	175	205	480~680	35	0.09	3t
06Cr17Ni12Mo2	S31608	205	245	520~720	35	0.09	3t
022Cr17Ni12Mo2	S31603	175	205	480~680	35	0.09	3t
06Cr19Ni13Mo3	S31708	205	245	520~720	35	0.09	3t
022Cr19Ni13Mo3	S31703	175	205	480~680	35	0.09	3t
06Cr18Ni11~~0~~Ti	S32168	205	245	520~720	35	0.09	3t
06Cr18Ni11Nb	S34778	205	245	520~720	35	0.09	3t

Notes: ① The tensile strength range for all grades in the Table is 200 N/mm^2.

② The proof strength values $R_{p1.0}$ are given for information purposes only and unless otherwise agreed, are not required to be verified by testing.

Mechanical Properties of Duplex Stainless Steel Table 4.6.4.1(2)

Grade	Uniform number code	Proof strength $R_{p0.2}$ min. (N/mm^2)	Tensile strength R_m min. (N/mm^2)	Elongation A_5 min. (%)	Flattening test constant C	Bend test diameter of former D
022Cr22Ni5Mo3N	S22253	450	620	25	0.09	$3t$①
022Cr23Ni5Mo3N	S22053	450	620	25	0.09	$3t$①
03Cr25Ni6Mo3Cu2N	S25554	490	690	25	0.09	$3t$①
022Cr25Ni7Mo4N	S25073	550	790	20	0.09	$4t$

Note: ① For bend tests carried out on the welds of the welding tubes, the diameter of the former may be $4t$.

4.6.5.1 ~~For materials used for piping systems of bulk chemical tankers, intercrystalline corrosion tests are to be carried out in accordance with the provisions given in Section 7, Chapter 2 of this PART and test specimens are to be prepared in accordance with the following requirements:~~

~~(1) 1% of the number of pipes is to be taken from each batch as specified in 4.1.6 of this Chapter, with a minimum of one pipe.~~

~~(2) For pipes with an outside diameter not exceeding 40 mm, the test specimens are to consist of a full cross-section. For larger pipes, the test specimens are to be cut as circumferential strips of full wall thickness and having a width of not less than 12.5 mm, in order that the total surface area of the test specimens is to be between 1,500 mm^2 and 3,500 mm^2.~~ For steel pipes having direct contact with corrosive chemicals, 1% of the number of pipes is to be taken from each batch as specified in 4.1.6 of this Chapter, with a minimum of one pipe, and test specimens are prepared and intercrystalline corrosion tests are carried out according to the provisions of Section 7, Chapter 2 of the Rules.

CHAPTER 5 STEEL FORGINGS

Section 3 FORGINGS FOR SHAFTING AND MACHINERY

5.3.1 Application

5.3.1.2 Where it is proposed to use alloy steel forgings, details of the chemical composition, mechanical properties and heat treatment process are to be submitted to CCS for approval~~, and the following requirements are to be complied with:~~

~~(1) for main propulsion shafting, the tensile strength is not to exceed 800 N/mm^2;~~

~~(2) for other machinery items, the tensile strength is not to exceed 1,100 N/mm^2~~.

5.3.2 Chemical composition

5.3.2.3 Where there are cleanliness requirements for forgings, concentration of hazardous elements and gas is to be strictly controlled.

5.3.4 Tests and test specimens

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

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

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

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

5.3.4.5 For alloy steel forgings which use R_m value greater than 800 N/mm^2 to calculate shaft diameter according to 11.2.2.1, PART THREE of the Rules for Classification of Sea-going Steel Ships and which have a tensile strength greater than 800 N/mm^2, but less than 950 N/mm^2 intended for use as intermediate shaft material, a test specimen for inclusion analysis is to be taken from the location as close to the head of the representative forging (or rolled piece) as possible in each heat. The specimen is to be analyzed in accordance with ISO 4967 method A and the inclusions are not to be greater than those required by Table 5.3.4.5.

Cleanliness Requirements for Forgings Table 5.3.4.5

Inclusion group	A		B		C		D		DS
Series	Fine	Thick	Fine	Thick	Fine	Thick	Fine	Thick	—
Limiting chart diagram index	1	1	1.5	1	1	1	1	1	1

CHAPTER 6 STEEL CASTINGS

Section 7 FERRITIC STEEL CASTINGS FOR LOW TEMPERATURE SERVICE

6.7.1 Application

6.7.1.1 This Section applies to castings in carbon-manganese and nickel alloy steels intended for use in liquefied gas piping systems where the design temperature is lower than 0℃, and for other applications where guaranteed impact properties at low temperatures are required.

6.7.2 Chemical composition

6.7.2.1 The chemical composition of ladle samples is to comply with the requirements given in Table 6.7.2.1.

Chemical Composition of Ferrite Steel Castings for Low Temperature Service Table 6.7.2.1

Steel type	Chemical composition (%)						
	C	Si	Mn	S	P	Ni	Other elements
Carbon-manganese steel	≤ 25	≤ 0.60	0.70 ~ 1.60	≤0.040.035	≤0.040.035	≤ 0.80	Cr ≤ 0.25 Cu ≤ 0.30
2.52.25Ni	≤ 0.25	≤ 0.60	0.50 ~ 0.80	≤0.040.03	≤0.040.03	2.0 ~ 3.0	
3.5Ni	≤ 0.15	≤ 0.60	0.50 ~ 0.80	≤0.040.03	≤0.040.03	3.0 ~ 4.0	

Note: Carbon-manganese steels are to be made by fine grain practice.

6.7.3 Heat treatment

6.7.3.1 Castings are to be heat treated as follows:

(1) normalized; or

(2) normalized and tempered; or

(3) quenched and tempered.

6.7.4 Mechanical properties

6.7.4.1 At least one group of test specimens is to be prepared from each casting or batch of castings.

6.7.4.2 One group of test specimens consists of one tensile test specimen and one set of three Charpy V-notch impact test specimens.

6.7.4.3 The mechanical properties of castings are to comply with the requirements given in Table 6.7.4.3.

Mechanical Properties of Ferrite Steel Castings for Low Temperature Service Table 6.7.4.3

Steel Type	Tensile strength R_m min. (N/mm^2)	Yield strength R_{eH} min. (N/mm^2)	Elongation A_5 min. (%)	Reduction of area Z min. (%)	Charpy V-notch impact test	
					Test temp. (℃)	Average energy min. (J)
Carbon-manganese steel	400	200	25	40	-40②	27
	430	215	23	35		
	460	230	22	30		
2.52.25Ni	490	275	20	35	-60-70	34
3.5Ni	490	275	20	35	-70- 95	34

Note: ① For castings with specified minimum a tensile strength < 430 N/mm^2, the tensile strength range is 100 N/mm^2. For all grades of castings with specified minimum tensile strength ≥ 430 N/mm^2, the tensile strength range is l50 N/mm^2.

② Test temperature is to be 5℃ lower than design temperature, or -20℃, whichever is lower. The specific test temperature is to be determined when the order is placed.

6.7.5 Non-destructive examination

6.7.5.1 The non-destructive examination of castings is to be carried out in accordance with the requirements indicated on the approved plans.

Section 8 AUSTENITIC STAINLESS STEEL CASTINGS

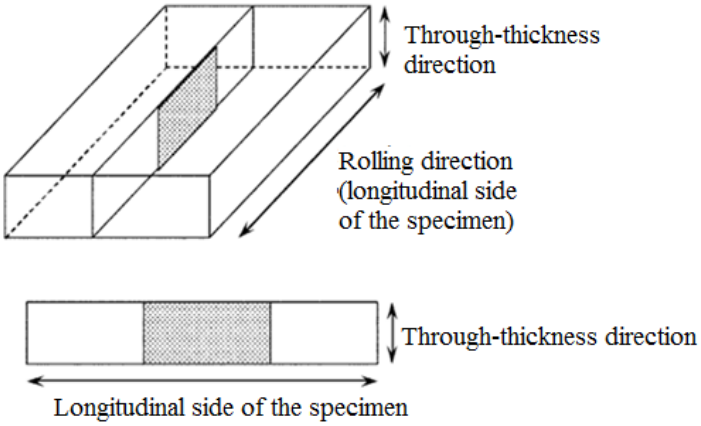
6.8.1 Application

6.8.1.1 This Section applies to castings in austenitic stainless steels for piping systems used in low-temperature environment (~~ships carrying liquefied gases~~ where the design temperature is not lower than -165℃, such as liquefied gas carriers) and corrosive environment (such as ~~in~~ bulk chemical tankers).

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 dash areas in the Figure are the corrosion and evaluation area respectively

Figure 8.2.6.5 Sampling of Corrosion Specimen

CHAPTER 10 EQUIPMENT

Section 1 ANCHORS

10.1.5.3 The proof test loads for anchors are to be determined in accordance with mass of anchor and comply with Table 10.1.5.3. For anchors of different types, t~~T~~he mass of anchors m_a given in the Table is to be taken as follows:

(1) for stockless anchors, the actual total mass;

(2) for stocked anchors, the actual mass of anchor excluding the stock;

(3) for high holding power anchors, ~~a nominal mass equal to~~ 1.33 times the actual mass is to be taken. Unless specifically agreed otherwise, the same applied to the mass of mooring anchors;

(4) for super high holding power anchors, ~~the nominal mass is to be~~ twice the actual mass is to be taken.

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

Requirements for Properties of Resin Chock Castings **Table 2.2.7.7**

Compressive strength N/mm^2	Compressive modulus N/mm^2	Barcol hardness	Heat deflection temperature ℃	Flammability	Water absorption① %	Oil absorption① %
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.

2.2.9 Cast epoxy putty for low-temperature tanks

2.2.9.1 Bi-component thermosetting epoxy putty used to bind saddle of low-temperature liquefied gas (such as LEG, LPG, LNG) tanks and supporting frame is subject to CCS approval before use.

2.2.9.2 Product manufacturers are to provide complete construction technical files, including recommended design principle, construction methods and requirements for reference.

2.2.9.3 Samples are to be cast in accordance with the construction procedures and the following performances are to be tested after the samples are set:

(1) Barcol hardness;

(2) density;

(3) compressive strength and compressive modulus of elasticity (tests are carried out at 20℃, -50℃, -110℃, -195℃);

(4) shearing strength (tests are carried out at 20℃, -50℃, -110℃, -195℃);

(5) linear expansion coefficient (-30℃~30℃);

(6) creep (at 70℃, for 2000 h, creep under 2.5 MPa and 7 MPa are tested respectively);

(7) compressive deformation (20℃, -195℃);

(8) compressive yield strength (20℃, -195℃).

CHAPTER 3 FIBER-REINFORCED PLASTIC HULL MATERIALS

Section 1 GENERAL PROVISIONS

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

3.2.3.1 The resins employed are to be unsaturated polyester resins, vinyl ester resins or epoxy resins approved for marine use. Where carbon fiber is used for hull, unsaturated polyester resins are not to be used.

PART THREE WELDING

CHAPTER 1 GENERAL

Section 2 TESTING

1.2.4.2 Bend tests are generally to be carried out at ambient temperature. A former, having a specified diameter and with its axis perpendicular to the center of the weld, is to be used to push and bend the specimen. Where the yield strength of the weld and parent metal, or of two parent metals, differs significantly (such as aluminium alloy, dissimilar steel joint), wrap around method bend test as indicated in Figure 1.2.4.2 is recommended. The face, root or side bend test is to be such that the bend test specimen is tested with the face, root or side of the weld in tension respectively. Unless otherwise specified, the diameter of the former and the bending angle are to be as follows:

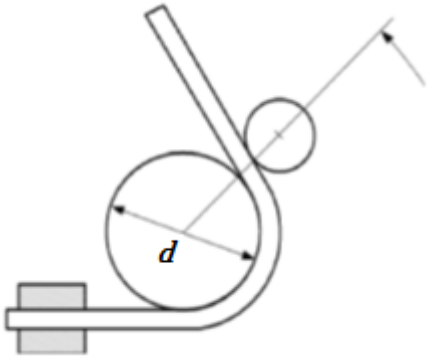


Figure 1.2.4.2 Wrap Around Method Bend Test

(1) Bend tests of structural steels are to comply with the requirements of Table 1.2.4.2(1).

Requirements for Bend Tests of Structural Steels **Table 1.2.4.2(1)**

Purpose of test	Specified yield strength of test material (N/mm^2)	Diameter d of former	Bending angle α
For approval of welding consumables	$R_{eH} \leq 400$	$3t$	120°
	$400 < R_{eH} \leq 500$	$4t$	
	$500 < R_{eH} \leq 690$	$5t$	
For approval of welding procedures	$R_{eH} \leq 400$	$4t$	180°
	$400 < R_{eH} \leq 500$	$5t$	
	$500 < R_{eH} \leq 690$	$6t$	

Notes: ① t is the thickness of the specimen.

② For approval test of welding procedures for boilers and pressure vessels, the former diameter is to comply with Table 7.2.3.4 of this PART.

(2) The ~~wrap-around~~ bend tests ~~using a roller method is recommended for~~ of aluminum alloy welds are to comply with~~, and~~ the following requirements ~~are to be complied with~~:

a. Tests for approval of welding consumables are to comply with the requirements of Table 2.9.3.7 of this PART.

b. The bending angle for approval tests of welding procedures is to be 180°, and the diameter of the former is not to be greater than the value obtained from the following formula:

$$d = \frac{(100 \times t_s)}{A} - t_s$$

where: d – maximum former diameter, in mm;

t_s – thickness of bend test specimens (including side bend specimens), in mm;

A – minimum tensile elongation required by the alloy grade, temper condition and thickness (for combinations of different alloys, the lowest individual value is to be used), in %.

(3) The bend tests of austenitic and duplex stainless steel welds are to comply with the following requirements:

a. Tests for approval of welding consumables are to comply with the requirements of Table 2.8.4.3 of this PART.

b. The bend tests for approval of welding procedures are to comply with the requirements of Table 1.2.4.2(3) of this PART.

Requirements for Bend Test of Austenitic and Duplex Stainless Steel Welds

Table 1.2.4.2(3)

Test material		Diameter of the former, d	Bending angle, a
Austenitic stainless steel		4t	180°
Duplex stainless steel	S22253 S22053	4t	180°
	S25554 S25073	6t	180°

Note: t is the thickness of the specimen.

CHAPTER 3 APPROVAL OF WELDING PROCEDURES

Section 2 WELDING PROCEDURE APPROVAL TESTS FOR BUTT WELDS

3.2.4.3 In addition to the tests required in 3.2.4.1 and 3.2.4.2 of this Section, the following examinations and test items may be required when deemed necessary by the Surveyor according to the actual situation:
(1) chemical analysis of deposited weld metal;
(2) chemical analysis of parent plate;
(3) micro-structure~~, at 100 and not lower than 300 magnifications,~~ of the welded joint~~;~~
~~(4) stainless steel intercrystalline corrosion test~~.

3.2.7 Additional requirements for welding procedures approval tests of stainless steels

3.2.7.1 For austenitic 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) generally only the center of the weld is subject to the impact test (test temperature is -20℃). In deep cold condition, 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 -196℃). The impact energy is not to be less than 27 J;
(2) the hardness test may be omitted;
(3) the intercrystalline corrosion test of welds is to be carried out in accordance with the requirements of Section 7, Chapter 2, PART ONE of the Rules (for austenitic stainless steel used in non-corrosive medium, it may be omitted).

3.2.7.2 For 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℃). 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%.

Section 3 WELDING PROCEDURE APPROVAL TESTS FOR FILLET WELDS

3.3.3 Test items

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/mm^2 (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.

3.3.3.3 Unless otherwise specified, the pipe-to-pipe and pipe-to-plate fillet weld assemblies are to be cut into four equal parts as shown in Figure 3.3.3.3(1) or (2). Each weld is to be subjected to macro examination

(at least one cross section is to include stop/restart points). For steels with specified minimum yield strength not less than 355 N/mm^2, the specimen with stop/restart points is also used for hardness test.

CHAPTER 4 QUALIFICATION TESTS OF WELDERS

Section 2 QUALIFICATION TESTS AND EVALUATION OF WELDERS

4.2.4 Test or inspection

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

Test or Inspection Items and Required Specimens **Table 4.2.4.1**

Type of assembly	Test or inspection items	Required specimens
Butt welding of plates	1. Visual inspection 2. Bend test and/or radiographic inspection①②	Visual inspection: weld length Radiographic inspection: examination length of weld③ Bend: one for face bend test and one for root bend test④
Butt welding of pipes	1. Visual inspection 2. Bend test and/or radiographic inspection①②	Visual inspection and radiographic inspection: weld length Bend: one for face bend test and one for root bend test④ at 1G and 2G; two for face bend test and two for root bend test④ at 5G, 6G and 6GR
Fillet welding of plates	1. Visual inspection 2. Fracture test or macro examination	Visual inspection: weld length Fracture: examination length of weld③ Macro: two
Pipe-to-plate fillet welds	1. Visual inspection 2. Macro examination	Visual inspection: weld length Macro: two
Tack welding	1. Visual inspection 2. Bend test	Visual inspection: all welding points Bend: the specimen is bent with backing strap in place and with face of the welds in tension

Notes: ① Bend test cannot be omitted for solid wire CO_2 gas-shielded welding and aluminum alloy welding ~~(including aluminum alloy)~~.

② Radiographic inspection + bend test for welders engaged in welding of marine boilers and pressure vessels.

③ The examination length of weld is the length deducted by 25 mm from both ends of the test assembly respectively.

④ If the thickness of the test assembly is not less than 12 mm, side bends may be used instead.

5.2.6 Welding of main engine seatings

5.2.6.1 Where the web thickness of the longitudinal girder of the main engine seating is equal to or greater than 14 mm, the edge of the web plate is to be beveled where it is connected to the horizontal face plate so as to achieve greatest fusion. The size and contour of fillet welds on both sides of the abutting plate are to be uniform and symmetrical.

5.2.6.2 For the fillet welds of other structural members (such as bottom plating, floors, tripping brackets, transverse webs etc.) attached to the main engine seating, the throat thickness is ~~not to be less than $0.44t_p$ (t_p being the thickness of the thinner one of the two members connected by fillet welding)~~to comply with the relevant requirements of Section 4, Chapter 1, PART TWO of CCS Rules for Classification of Sea-going Steel Ships.

CHAPTER 7 WELDING OF PRESSURE SHELLS

Section 1 GENERAL PROVISIONS

7.1.1 Application

7.1.1.1 This Chapter applies to the welding and survey of pressure shells of enclosed structures which are subjected to internal pressure or external pressure, such as boilers and pressure vessels, diving systems and submersibles. The welding and survey of type C independent tanks and process pressure vessels of ships carrying liquefied gases in bulk are to comply with Chapters 4 and 6 of CCS Rules for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

7.1.1.2 This Chapter ~~only~~ applies to welded joints of carbon steel, ~~and~~ low alloy steel, austenitic and duplex stainless steel pressure vessels made by a manual, semi-automatic or automatic arc welding process. Where it is proposed to use other welding processes, details are to be submitted to CCS for approval.

7.1.1.3 Where materials other than those specified in 7.1.1.2 are used, the testing, manufacturing and survey are to meet the requirements of recognized standards.

7.1.3 Approval

7.1.3.1 Manufacturers of pressure shells (excluding Class III pressure vessels) are to apply to CCS for works approval.

Section 2 PRODUCTION WELDING TESTS OF PRESSURE SHELLS

7.2.3 Specimens and testing

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
6~8	Impact test for center of the weld ②	Required	

Notes: ① Where a test plate is greater than 20 mm 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 ~~for pressure shells of diving systems and submersibles.~~ in the following conditions:

a. pressure shells of diving systems and submersibles;

b. all pressure shells with design temperature at 0℃ and below;

c. pressure shells made of alloy steels (excluding austenitic stainless steel).

7.2.3.4 For bend tests, the diameter of the former and the clear space between the supports are to comply with the requirements given in Table 7.2.3.4.

~~**Former Diameter and Space between Supports** **Table 7.2.3.4**~~

~~Min. specified tensile strength R_m of test plate (N/mm^2)~~	~~Diameter of former~~	~~Clear space between supports~~
~~$R_m < 460$~~	~~$2t$~~	~~$4.2t$~~
~~$460 \leq R_m < 510$~~	~~$3t$~~	~~$5.2t$~~

~~Note: t being the plate thickness, in mm.~~

Former Diameter and Space between Supports **Table 7.2.3.4**

Min. specified elongation of parent metal A_5 (%)	Diameter of former(mm)	Clear space between supports(mm)
$A_5 \geq 20$	$4t$ ①	$6t+3$ ①
$A_5 < 20$	d ②	$d+2t+3$ ①②

Notes: ① t being the plate thickness, in mm.

② $d = \dfrac{(100 \times t)}{A_5} - t$, in mm.

7.2.4 Acceptance and re-tests

7.2.4.1 The results of various tests are to comply with the requirements given in Table 7.2.4.1.

Requirements for Production Welding Tests **Table 7.2.4.1**

Test	Pressure shells	
	Class I	Class II
Deposited metal tensile	(1) Tensile strength ~~R_m~~: not less than the minimum specified tensile strength of the parent metal or comply with the technical requirements specified by the design document~~and not more than 145 N/mm^2 above this value~~. (2) Elongation ~~A_5~~: ~~$A_5 \geq (980 - R_m)/21.6$. In addition, this elongation is not to be less than 80% of the equivalent minimum elongation specified for the parent metal~~not less than the following two values, whichever is less: 20%; $4820/R_m + 10$ (R_m is the minimum specified tensile strength of the parent metal)	
Bend	The diameter of the former and the clear space between supports are to be in accordance with Table 7.2.3.4. A former with its axis perpendicular to the specimen is to bend the specimen by pushing it through the clear space between the supports. After bending, there is to be no open defect in any direction exceeding 3 mm in dimension on the outer surface of the bent portion	
Butt weld transverse tensile	Butt weld tensile strength is not to be less than the minimum specified tensile strength of the parent metal, or comply with the technical requirements specified by the design document	
Macro examination	No cracks, incomplete penetration, lack of fusion and significant slag inclusions or other defects	
Impact	~~For testing at ambient temperature, t~~The average energy obtained is not to be less than the value required for the parent metal~~27 J~~①	Not required

Note: ①Impact specimens for pressure shells are to be tested at temperatures required according to their parent metals, except that those for boilers and normal temperature pressure vessels are to be tested at ambient temperature. For the temperature for impact tests for stainless steel pressure vessels, refer to 3.2.7, Chapter 3 of the Rules.

7.2.4.2 If any of the tests fail, the reason for the failure is to be investigated and ~~two~~ additional specimens are to be prepared from the original specimen for re-tests. The number of specimens is to comply with the requirements of 1.2.5.2 and 1.2.5.3, Chapter 1 of this PART.

Section 3 MANUFACTURE AND WORKMANSHIP OF PRESSURE SHELLS

7.3.2 Edge preparation

7.3.2.1 Where plate edges of pressure shells are to be joined by welding, they are to be well beveled. Edges may be prepared by ~~gas~~flame cutting, plasma cutting, machining, chipping or grinding. Where ~~gas~~flame cutting is employed, any remaining slag and scale are to be removed by machining or grinding from the beveled edges. For austenitic and duplex stainless steels, flame cutting is to be avoided.

7.3.4 Welding

7.3.4.13 Where austenitic or duplex stainless steels are used in pressure vessels, relevant requirements of Section 4, Chapter 5 of this PART are to be complied with in addition to the requirements above.

Section 4 HEAT TREATMENT

7.4.1 General requirements

7.4.1.4 Unless otherwise specified by the design document, welding joints of austenitic and duplex stainless steels may not be heat treated.

Section 5 INSPECTIONS AND REPAIRING

7.5.4 Non-destructive testing of welds

7.5.4.1 The welds in pressure shells are to be subjected to non-destructive examination. The method, number and location of the examination are to comply with the requirements of Table 7.5.4.1. The procedures of the non-destructive examination are to be agreed by CCS.

Testing Requirements for Pressure Vessels **Table 7.5.4.1**

Method	Boilers and general pressure vessels		Diving systems and submersibles
	Class I	Class II	
Radiographic testing	Examination 100% for all longitudinal and circumferential butt welds① in shells, drums, headers and pipes and tubes together with test plates	100% for test plates and at least 10% for butt welds	100% for butt welds of the shell
	Butt welds in furnaces, combustion chambers and similar pressure components are to be subjected to spot radiographic examination		
Ultrasonic testing	Where the plate thickness exceeds 50 mm, ultrasonic testing may be accepted as an alternative to radiographic examination, subject to agreement of CCS. If necessary, examination by radiography is to be required at selected locations. 100% for full penetration fillet welds on pressure shells		100% for full penetration fillet welds of the shell
Magnetic particle or dye penetrant testing③	The welds on standpipes, compensating plates, stubs and branches which have not been radiographically tested are to be subjected to magnetic particle or dye penetrant examination for 10% of such welds. The number and locations for testing may be increased by the Surveyor if necessary		Random testing on 10% of aggregated weld length; 100% for strengthened welds at openings and piping connections

Notes: ① For tubular parts of 170 mm or less in outside diameter, 25% of circumferential butt welds in headers and 10% of circumferential butt welds in other pipes are to be subject to radiographic testing.

② The non-destructive testing of Class III pressure vessels may be required by the Surveyor at his discretion according to their specific purposes.

③ For low-temperature pressure vessels, 100% of full penetration fillet welds between connection pipes with external diameter ≤57 mm and pressure shells are to be subject to magnetic particle or dye penetrant testing.

7.5.4.5 The technical grade of ~~sensitivity for~~ radiographic ~~examination~~ and ultrasonic testing is to comply with the requirements of applicable grade of recognized standards. The sensitivity, optical density and geometric un-sharpness for radiographic examination are to comply with the following:

(1) For the use of image quality indicators of the step/hole type, the radiographical sensitivity requirements are given in Table 7.5.4.5(1).

(2) For the use of image quality indicators of the wire type, the radiographical sensitivity requirements are given in Table 7.5.4.5(2).

(3) Unless specified otherwise, the optical density of the film is generally to be between 2.0~4.5.

(4) Geometric un-sharpness $f \geq 10d \cdot b^{2/3}$

where: f—distance from the radiation source to the work piece surface;

d—effective focus size;

b—distance from the work piece to the film.

Radiographical Sensitivity Requirements for Image Quality Indicators of Step/Hole Type

Table 7.5.4.5(1)

Nominal thickness of workpiece (mm)	Hole no. visible in the radiograph (hole diameter, in mm)

$3.5 < t \leq 6$	H5 (0.320)
$6 < t \leq 10$	H6 (0.400)
$10 < t \leq 15$	H7 (0.500)
$15 < t \leq 24$	H8 (0.630)
$24 < t \leq 30$	H9 (0.800)
$30 < t \leq 40$	H10 (1.000)
$40 < t \leq 60$	H11 (1.250)
$60 < t \leq 100$	H12 (1.600)
$100 < t \leq 150$	H13 (2.000)

Radiographical Sensitivity Requirements for Image Quality Indicators of Wire Type

Table 7.5.4.5(2)

Nominal thickness of workpiece (mm)	Wire no. visible in the radiograph (wire diameter, in mm)
$3.5 < t \leq 5$	W15 (0.125)
$5 < t \leq 7$	W14 (0.16)
$7 < t \leq 10$	W13 (0.20)
$10 < t \leq 15$	W12 (0.25)
$15 < t \leq 25$	W11 (0.32)
$25 < t \leq 32$	W10 (0.40)
$32 < t \leq 40$	W9 (0.50)
$40 < t \leq 55$	W8 (0.63)
$55 < t \leq 85$	W7 (0.80)
$85 < t \leq 150$	W6 (1.00)

7.5.4.7 The sensitivity for ~~ultrasonic and~~ magnetic particle testing is to be selected based on the specific location of testing and agreed by the Surveyor.