ClassIBS

ISTHMUS BUREAU OF SHIPPING

PART 10
MATERIALS

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PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUTION OF STEEL SHIPS

PART 10 MATERIALS

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PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS

PART 10 MATERIALS

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1. All materials subject to test and inspection, intended for use in the construction of hulls and equipment of vessels classed or proposed for classification, are to be to the satisfaction of the IBS Surveyor and in accordance with the following requirements or their ***Equivalent***.

2. The requirements in this part apply to the materials intended to be used for the members or components specified in each part of hull construction, equipment and machinery.

3. Materials having characteristics differing from those specified in this part may be used when the detailed design data, manufacturing procedure and their use are specially approved by the Society, due regard being given to established practices in the country in which the material is produced and the purpose for which the material is intended, such as the parts for which it is to be used, the type of vessel and intended service, and the nature of the construction of the vessel.

In this case, detailed data relating to the manufacturing process, performance, etc. of the materials are to be submitted for approval to the Society.

1.2 Manufacture and Approval of Materials

1.2.1 Manufacture of Materials

1. The materials specified in this part, unless otherwise specially provided or deemed appropriate by the Society, are to be manufactured at the works approved by the Society with regard to the manufacturing process of the materials. The steel material is to be manufactured by basic oxygen convertor, electric furnace or other processes specially approved by the Society.

2. Primary materials such as ingot, slab or billet supplied to other works are to be in accordance with the requirement of preceding **-1** as appropriate.

3. Materials differing from those specified in this part are to be in accordance with the requirements of preceding **-1** when deemed necessary by the Society.

1.2.2 Approval of Manufacturing Process

1. Approval of manufacturing process specified in **1.2.1** is to be in accordance with the requirements of and Type Approval of Materials and Equipment for Marine Use.

2. Where controlled rolling (*CR*) and thermo-mechanical rolling (*TM*) with/without accelerated cooling (*AcC*) are specially applied, the programmed rolling schedules are to be verified by the Society.

1.3 Manufacturing Control of Material

1.3.1 Operation of Manufacturing Control

1. It is the manufacturer's responsibility to assure that effective process and production controls in operation are adhered to. The manufacturer is especially to adhere to the following requirements;

(1) Where deviation from the controls occurs and/or inferior quality of products exists, the manufacturer is to identify the cause and establish a countermeasure to prevent its recurrence. Also, the complete investigation report is to be submitted to the Surveyor. In this case, each affected piece is to be tested and inspected according to the Surveyors direction.

(2) Where *CR* and *TM* with/without *AcC* are applied, the manufacturer is adequately to control these programmed rolling schedules in accordance with the approval condition and is to verify the validity of the control by means of the investigation of the actual rolling records.

2. The manufacturer is to take a suitable measure for identification of ingots, slabs, castings, forgings and finished pieces, etc. which will enable the material to be traced to the processing details as melting, rolling, forging, heat treatments, etc. at all phases of manufacturing process.

1.3.2 Verification of controls

1 Where the Surveyor deems necessary or the matter specified in **1.3.1-1(1)** was reported, it is to be verified that the approved process is adhered to and the manufacturing control is effective. In this case, the manufacturer is to afford the Surveyor all necessary facilities and access to all relevant parts of the works.

2 Where deviation from the controls is discovered by the verification specified in **-1**, the Society's Surveyor may require a report of investigation on the substantial cause and the increasing of the frequency of subsequent testing and inspection.

1.4 Testing and Inspection for Materials

1.4.1 Execution of Testing and Inspection

1. Testing and inspection for materials specified in this part are to be carried out in the presence of the Society's Surveyor at the steelworks prior to delivery except where otherwise specially provided, and are to comply with the requirements of **Chapter 3** to **8** in this part.

2. The manufacturer is to show the following data to the Surveyor prior to testing and inspection for materials.

(1) Material specifications (including special requirements, etc.)

(2) a certificate which states the name of manufacturer who supplied primary materials, melting, casting and the other manufacturing processes, the number of the cast and chemical composition (ladle analysis) (only if primary materials such as ingot, slab or billet are not produced at the works at which it is rolled, piped or forged)

3. The chemical composition is to be analyzed at an adequately equipped and completely staffed laboratory. The testing machines used for the mechanical testing of material are to be those which have the effective certificates issued by the Society or other organization recognized by the Society in accordance with the standards deemed appropriate by the Society.

4. The Society may dispense with the tests and inspections for materials having the appropriate certificates.

5. The Society may modify the requirement of presence of testing and inspection by the Surveyor where the quality of materials and the quality control system of manufacturer are deemed appropriate by the Society.

1.4.2 Standard for Testing and Inspection

1. The materials are to comply with the requirements of **Chapter 3** to **8** in this part.

2. The chemical composition is to be analyzed on samples generally taken from each melt. A check analysis may be required by the Society where deemed necessary.

3. Materials differing from those specified in this part are to be tested and inspected according to the approved specifications or standards for the testing.

4. The Society may request tests under different conditions or different kind of tests specified in this part in consideration of the intended service condition of the materials.

1.4.3 Quality and Repair

1. All materials are to be free from harmful defects. Repairing of defects is not permitted unless the extent and method of repair (including welding procedure and heat treatment) are approved by the Surveyor.

2. In the event of any material proving unsatisfactory in the process of being worked, it is to be rejected, notwithstanding any previous certificate of satisfactory testing and inspection where the Surveyor considers necessary.

1.4.4 Additional Tests before Rejection

1. Where part of the results of any mechanical test except impact test does not conform to the requirements, but the remainders are satisfactory, additional test specimens twice in number may be taken from the same material and re-tests for the failed test may be carried out. In such a case, all of the test specimens are to conform to the Rule requirements.

2. Where the results of impact test do not conform to the requirements, additional tests are to be carried out in accordance with the requirements in each Chapter.

3. If a heat treated material fails to meet the requirements in any test, re-tests may be allowed after being heat treated again. In this case, however, the material is not to be considered as having complied with the requirements unless all tests fully comply with the test requirements.

4. If the percentage of elongation of any tensile test specimen is less than that specified and any part of fracture is outside the one-fourth of the gauge length from the centre of gauge length, the test is to be considered as invalid, and an additional test for the material from which the first test specimen has been taken may be allowed.

1.5 Marking and Test Certificate

1.5.1 Marking

1. Every materials complying with the requirements is to be clearly stamped with the Society's brand including the marks deemed appropriate by the Society and material grade mark, and marked with the following particulars in at least one position by the maker.

a. Name or mark to identify the maker.

b. Number or mark to identify the piece.

c. Name, order number or other identification marks (if required by the purchaser)

2. Materials which are unsuitable for stamping may be marked with brands, seals or by other suitable means.

3. Materials which cannot be stamped and marked in accordance with the requirements in **-1** and **-2** due to small size may be properly marked in the lump.

1.5.2 Test Certificate

1. The manufacturer is to submit test certificate on the rolled steel materials which have passed the specified test and inspection requirements for each material mark for the Surveyor's signature. However, another method may be used instead of Surveyor's signature, provided that it is deemed appropriate by the Society.

2. The test certificate specified in **-1** are to contain, in addition to the dimensions, mass, etc., of the steel material, at least items **(1)** through **(9)** of the following particulars:

(1) Purchaser's order number and if known the ship number which the material is intended;

(2) Identification number or symbol;

(3) Identification of manufacturer;

(4) Identification of grade of material;

(5) Chemical Composition (ladle analysis on elements specified in the requirement and added when necessary)

(6) Carbon equivalent (C_{eq}) or cold cracking susceptibility (P_{cm}) calculated from the following formula using ladle analysis (only in such a case as specified in this part.);

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

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

(7) Mechanical test results;

(8) Condition of heat treatment (e.g. normalized or controlled roll except for as rolled);

(9) Deoxidation practice is to be stated (rimed steel only).

3. The manufacturer is to enter the following statement on the certificate to show that the steel material has been made by an approved process, and the declaration is to be signed by the personnel of the manufacturing shop in charge of product quality control or inspection. However, another method may be used instead of the signature of the person in charge, provided that it is deemed appropriate by the Society.

(Example)

We hereby certify that the material has been made by an approved process and has been satisfactorily tested in accordance with the Rules of Isthmus Bureau of shipping.

4. The requirements in **-1** to **-3** are to be applied to the materials which are specified in this part but which are other than rolled steel materials.

Chapter 2 TEST SPECIMENS AND MECHANICAL TESTING PROCEDURES

2.1 General

2.1.1 Application

1. Test specimens and mechanical testing procedures for materials are to comply with the requirements in this Chapter, unless otherwise specially provided in and after the next Chapter.

2. Where specimens and mechanical testing procedures differing from those prescribed in this part are used, they are to be approved by the Society.

3. Test samples are to be cut and test specimens are to be collected, according to each requirement specified in and after the next Chapter.

2.2 Test Specimens

2.2.1 Preparation of Test Specimens

1. Except where otherwise specified or agreed with the Surveyor, test samples are not to be detached from the material until being stamped by the Surveyor.

2. If test samples are cut from material by flame cutting or shearing, a reasonable margin is required to enable sufficient material to be removed from the cut edges during final machining.

3. The preparation of test specimens is to be done in such a manner that test specimens are not subjected to any significant cold straining or heating.

4. If any test specimen shows defective machining or defects having no relation to the substantial nature, it may be discarded and substituted by another test specimen.

2.2.2 Tensile Test Specimens

1. Tensile test specimens are to be of size and dimensions given in **Table 2.1** and the both ends of the test specimen may be machined to such a shape as to fit the holder of the testing machine.

2. The manufacturers may use the test specimens approved by the Society, besides those specified in **Table 2.1**.

In this case, the required elongation is to be calculated from the following formula:

$$n = \text{a. E.} \left(\frac{\sqrt{\text{A}}}{\text{L}} \right)^{b}$$

n : Required elongation of test specimen

E : Required elongation for the proportional specimens specified in **Table 2.1**

A : Actual sectional area of test specimen

L : Actual gauge length of test specimen

a, b : Constants given in **Table 2.2** in accordance with the kind of materials.

3. The permissible variation (difference between the maximum and minimum values) at the machine-finished parallel part of test specimens is to be as specified in **Table 2.3**.

2.2.3 Bend Test Specimens

Bend test specimens are to be of size and dimensions given in **Table 2.4** according to the kind of materials.

2.2.4 Impact Test Specimens

1. Impact test specimens are to be provided in a set of three pieces.

2. Impact test specimens are to be of size and dimensions given in **Fig. 2.1** and **Table 2.5**. The notch is to be cut in a face of the specimen which was originally perpendicular to the rolled surface.

3. The position of the notch is not to be nearer than 25 *mm* to a flame-cut or sheared edge.

4. Where *U*4 impact test specimen having the size specified in above **-2** cannot be taken because of the thickness of material, the width *W* of the test specimen may be reduced to the dimensions given in **(1)** or **(2)** below, according to the thickness of material.

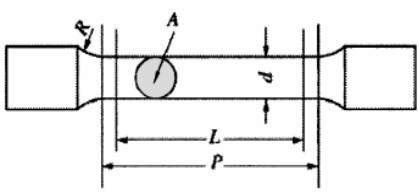
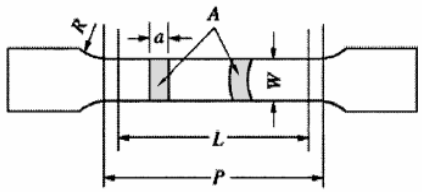
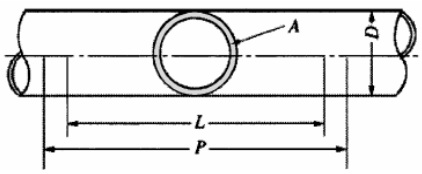
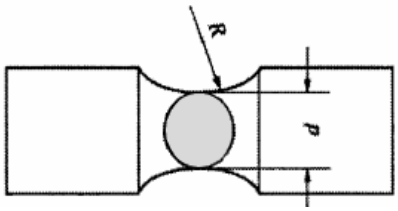
(1) Refer to **Table 2.6** for rolled steel materials.

(2) Refer to **Table 2.7** for steel pipes.

2.2.5 Confirmation for Test Specimens

The size and dimensions of test specimens are to be carefully inspected and verified by suitable means before testing.

Table 2.1 Size and Dimensions of Tensile Test Specimens (Unit: *mm*)

Kind	Size of specimens	Dimensions (1)(2)	Materials to be applied
*U*14*A*		*L*=70, *d*=14, *P*≅80, *R*≥ 10 (For spheroidal or nodular graphite iron castings, *R*≥ 20). The above-mentioned specimen is generally used, however, a specimen having the following dimensions may also be used: *L*=5*d*, *P*≅*L*+0.5*d*, *R*≥ 10 (For spheroidal or nodular graphite iron castings, *R*≥ 20).	Rolled steels (Chapter **3**) Steel pipes (Chapter **4**) Steel castings (Chapter **5**) Spheroidal or nodular graphite iron castings (Chapter **5**) Steel forgings (Chapter **6**) Cooper alloys(3) (Chapter **8**)
*U*14*B*		$L = 5.65\sqrt{A}$, $a = t$, W≥ 12 $P \cong L + 2W$, $R \geq 25$	Steel pipes (Chapter **4**) Cooper pipes (Chapter **7**)
		$L = 5.65\sqrt{A}$, $a = t$, W= 25 $P \cong L + 2\sqrt{A}$, $R \geq 25$	Rolled steels 3 *mm* and over in thickness (Chapter **3**) Aluminium alloys (Chapter **8**)
*U*1		$L = 200$, $a = t$, W= 25, $P \cong 220$, $R \geq 25$	
*U*13*B*		$L = 50$, $a = t$, $W = 12.5$, $P \cong 75$, $R \geq 25$	Rolled steels under 3 *mm* in thickness (Chapter **3**)
*U*14*C*		$L = 5.65\sqrt{A}$, $P \cong L + 0.5D$, where *P* is the distance between the end grips	Steel pipes (Chapter **4**) Cooper pipes (Chapter **7**)
*U*8		$d = 20$, $R = 25$ The specimen is to be prepared from test assembly, 30 *mm* in diameter, separately casted.	Grey iron castings (Chapter **5**)

Notes:

1 The following designations are used;

d: diameter, *a*: thickness, *W*: width, *L*: gauge length (Recommended to be 20 *mm* and over), *P*: parallel part length,

2 *A*: cross-section, *R*: transition radius, *D*: external tube-diameter, *t*: thickness of material

When $L = 5d$ or $5.65\sqrt{A}$, the specimen is called a proportional test specimen. The gauge length may be rounded off the nearest 5 *mm* provided that the difference between this length and *L* is less than 10% of *L*.

3 Except Aluminium alloys of thickness 12.5 *mm* and less.

Table 2.2 Values of *a* and *b*

Material	Constant	
	a	*b*
Material I	2.0	0.40
Material II	2.6	0.55

Notes:

1 Material I: For carbon and low alloy steels with a specified tensile strength not exceeding 600 N/mm^2 in the hot rolled, annealed, normalized or normalized and tempered conditions.

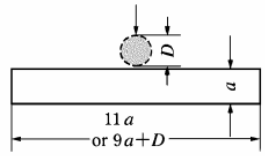
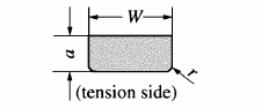
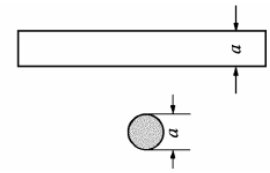
2 Material II: For carbon and low alloy steels in the quenched and tempered condition.

3 The values of *a* and *b* for other kinds of materials than Material II are to be as deemed appropriate by the Society.

Table 2.3 Permissible Variation

Diameter of test specimens where they are machined to a circular section, or thickness and width where they are machined to a rectangular section (mm)	Permissible variation (*mm*)	
	Circular cross section	Rectangular cross section
Over 3 up to 6	Max. 0.03	Max. 006
Over 6 up to 16	Max. 0.04	Max. 008
Over 16	Max. 0.05	Max. 0.10

Table 2.4 Size and Dimensions of Bend Test Specimens (Unit: *mm*)

Kind	Size of specimens	Size of specimens[1]	Materials to be applied
*U*1*A*		$a = t$ $W = 30$ $r = 1\sim2$	——— (2)
*U*1*B*		$a = 20, W = 25$ $r = 1\sim2$	Headers (Chapter **4**)
2		$a = d$ Where the diameter or the width across flat of materials exceeds 35 *mm*, they may be machined finished to a circular section of diameter not less than 35 *mm*	——— (2)

Notes:

The following designations are used;

1 *a*: Thickness, diameter or width of test specimen, *W*: Width of test specimen
d: Diameter or width across flats, *r*: Edge radius of test specimen
D: Diameter of mandrel, *t*: Material thickness

2 Materials deemed necessary by the Society.

Fig. 2.1 Impact Test Specimen

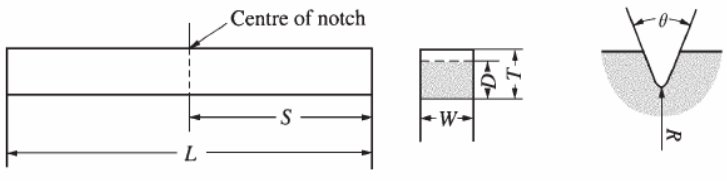


Table 2.5 Dimensions of Impact Test Specimens

Dimensions of test specimen		Kind of test specimen
		*U*4
		Charpy 2 *mm* V-notch test specimen
Length (*mm*)	*L*	55±0.6
Width (*mm*)	*W*	10±0.11
Thickness (*mm*)	*T*	10±0.06
Angle of notch (deg)	*θ*	45±2
Depth below notch (*mm*)	*D*	8±0.06
Root radius of notch (*mm*)	*R*	0.25±0.025
Distance of notch from end of test specimen (*mm*)	*S*	27.5±0.42
Angle between plane of symmetry of notch and longitudinal axis of test specimen (deg)	_	90±2
Materials to be applied	_	All materials

Table 2.6 Width of Subsize Test Specimen (for rolled steel plates)

Thickness of plate	Width of impact test
t(mm)	specimens *W* (mm)
$t<6$	_ (1)
$6 \le t < 8.5$	5 ± 0.06
$8.5 \le t < 11$	7.5 ± 0.11

Note:

1 The impact test may be omitted.

Table 2.7 Width of Subsize Test Specimens (for steel tubes)

Thickness of plate	Width of impact test
c (*mm*) (1)	specimens *W(mm)*
c <5 (2)	-
5 ≤ c <7.5	5 ± 0.06
7.5 ≤ c <10	7.5 ± 0.11

Notes:

1 *c* is to be calculated by the following formula

$$c = at - 1 - \frac{d-\sqrt{d^2-b}}{2}$$

a and *b* : Constants determined according to the kind of steel pipe and the point of collection of test specimen. Refer to **Table 2.8.**

t : Nominal thickness (*mm*) of steel pipe

d : Outside diameter (*mm*) of steel pipe

2 The impact test may be omitted.

Table 2.8 Values of *a* and *b*

Kind and position for selection		Constant	
		a	*b*
Hot-working seamless steel pipe		0.875	100
Cold- working seamless steel pipe		0.9	100
Electric-resistance	base metal	0.9	100
Welded steel pipe	Welded part	0.9	3025

2.3 Mechanical Testing Procedures

2.3.1 Tensile Test

1. The value of yield stress is to be measured at the first peak obtained during yielding.

2. When no well-defined yield phenomena exist, the proof stress is to be the strength of the 0.2% permanent elongation.

3. Where the value of yield stress or proof stress is measured at tensile test, the test is to be carried out with an elastic stress rate, 2~20N/mm^2 *per sec*, for a material of which modulus of longitudinal elasticity is less than 150000N/mm^2 and, 6~60N/mm^2 *per sec*, for a material of which modulus of longitudinal elasticity is not less than 150000N/mm^2.

4. For ductile material, the machine speed during the tensile test is not to exceed that corresponding to a strain-rate at maximum load of 0.8%/*sec*. For brittle materials such as cast iron, the elastic stress-rate is not to exceed 10 N/mm^2 per sec.

2.3.2 Impact Test

The impact test is to be conducted on a Charpy impact testing machine having a capacity not less than 150 *J* and a striking velocity between 4.5 and 6 *m*/*s*. with the test specimens at the temperature controlled with in ±2°C of the specified temperature.

The minimum average absorbed energy of the sub-sized test specimen is to be the value (by counting fractions of 0.5 and over as 1.0 and disregarding the rest) obtained from multiplying the value for the *U*4 impact test specimen by a coefficient given in **Table 2.9** according to the width of the test specimen.

Table 2.9 Multiplier to absorbed Energy for *U*4 Specimen

Width of impact test	Constant
Specimens W (mm)	
7.5	5/6
5	2/3

Chapter 3 ROLLED STEELS

3.1 Rolled Steels for Hull

3.1.1 Application

1. The requirements of this chapter are to apply to hull structural rolled steels (hereinafter referred to as "steels" in 3.1) not exceeding 50 *mm* in thickness.

2. Steels having thickness over 50 *mm* up to 100 *mm* are to comply with the requirements of 3.10. The requirements for steels having thickness exceeding 100 *mm* are to the discretion of the Society.

3. Steels having characteristics differing from those specified in 3.1 are to comply with the requirements in 1.1.1-2.

3.1.2 Kinds

The steels are classified into 16 *grades* as given in Table 3.1.

3.1.3 Deoxidation Practice and Chemical Composition

1. The deoxidation practice and chemical composition of each grade are to comply with the requirements given in Table 3.1. When thermo-mechanical controlled processing (a heat treatment based on controlled rolling approved by the Society; hereinafter referred to as "*TMCP*") is used as heat treatment, the requirement on the chemical composition of steel may be modified subject to the approval by the Society.

2. The cold cracking susceptibility of steels may be required to be submitted when specially required by the Society.

3.1.4 Heat Treatment

The heat treatment of each grade is to comply with the requirements given in Table 3.3.

3.1.5 Mechanical Properties

The mechanical properties of steels are to comply with the requirements given in Table 3.4.

3.1.6 Selection of Test Samples

1. For the samples of steel from which tensile test specimens are cut, except where specially approved by the Society, steels not greater in weight than 50 *ton* (where the amount of scatter is to be less than 10 *mm* in thickness or diameter even when they belong to the same charge in the same manufacturing process) are to be treated as one lot, and the largest one in thickness or diameter is to be selected from each lot.

2. One set of test samples largest in thickness are to be selected from each lot specified in Table 3.6, according to the substance of deoxidation practices, the type of products, and the kind of heat treatments.

3. The samples of steel are to be treated together with and in the same way as the steel presented and are not to be cut from the material until heat treatment has been completed.

4. The test samples are to be taken from the following portions according to the requirements **(1)** to **(3)** below and **Fig. 3.1,** unless otherwise specified:

(1) Plates and flat bars wider than 600 *mm*:

One end at a portion approximately 1/4 of the width from the flange end of the plates or flat bars.

(2) Shapes and flat bars not exceeding 600 *mm* in width:

One end at a portion approximately 1/3 (1/6 for H-sections) of the width from the flange end. In case of channels, unequal angles, and H-sections, the test samples may be taken from the portion approximately 1/4 (1/6 for bulb flats) of the depth from the centre line of the web.

(3) Bars:

The test samples are to be taken so the axis of each test specimen may lie as near as possible to the portion specified in **(a)** and **(b)** below. This rule, however, does not apply when, because dimensions of cross section are insufficient for standard test specimens, a piece cut in a proper length from the product having the largest diameter of a certain lot is used as it is for a tensile test.

(a) For non-circular sections, at approximately 1/6 of the largest distance from the outside.

(b) For circular section, at approximately 1/3 of the radius from the outside.

Table 3.1 Grades, Deoxidation Practice and Chemical Composition of Steels

Kind	Grade	Deoxidation Practice	Chemical Composition(%)[1]														Carbon equivalent (%)
			C	*si*	*Mn*	*P*	*S*[14]	*Cu*	*Cr*	*Ni*	*Mo*	*Al*[8]	*Nb*	*V*	*Ti*	*N*	
Mild Steels	*KA*	Any method except rimmed	*0.21 max* (4)(5)	0.5 max	2.5 x C min [4]	0.035 max	0.035 max	-	-	-	-	-	-	-	-	-	-
	KB		0.21 max[4]	0.35 max	0.80 min[4][6]												
	KD	Killed [2] or killed and fine grain			0.60 min[4]							0.015 min[3][11]					
	KE	Killed and fine grain	0.18 max[4]		0.70 min[4]							0.015 min[11]					
High tensile steels	*KA32*	Killed and fine grain treated	0.18 max	0.50 max	0.90-1.60[7]	0.035 max	0.035 max	0.35 max	0.20 max	0.40 max	0.08 max	0.015 min[9]	0.02 -- 0.05 [9] [10]	0.05-0.10[9] [10]	0.02 Max [10]	-	[13]
	KD32																
	KE32																
	KA36																
	KD36																
	KE36																
	KA40																
	KD40																
	KE40																
	KF32		0.16 max			0.025 max	0.025 max			0.80 max						0.009 Max [12]	
	KF36																
	KF40																

Notes:

1 Where additions of any other element have been made as part of the steel making practice, the content is to be indicated on the test certificate.

2 For steels up to 25 *mm* in thickness, killed steel may be accepted.

3 For steels over 25 *mm* in thickness, aluminium treatment is to be used as a killed and fine grain treatment.

4 The value of *C +Mn* /6 is not to exceed 0.40%.

5 For steels sections, maximum carbon content may be increased to 0.23%.

6 When an impact test is conducted or when steels contain *Si* not less than 0.10%, the minimum manganese content may be reduced to 0.60%.

7 For steels up to 12.5 *mm* in thickness, the minimum manganese content may be reduced to 0.70%.

8 Aluminium content is to be represented by the acid soluble aluminum content, but may be determined the total aluminium content. In such a case, the total aluminium content is not to be less than 0.020%.

9 The steel is to contain aluminium, niobium, vanadium or other suitable grain refining elements, either singly or in any combination. When used singly, the steel is to contain the specified minimum content of the grain refining element. When used in combination, the specified minimum content of each grain refining element is not applicable.

10 The total niobium, vanadium and titanium content is not to exceed 0.12%.

11 Upon the approval by the Society, grain refining elements other than aluminium may be used.

12 The maximum content of nitrogen may be increased to 0.012% if aluminium is present.

13 Carbon equivalent is to be recorded on test certificate. When any grade of higher strength steel is supplied in *TMCP* condition, the carbon equivalent is to comply with the requirements of **Table 3.2**.

14 For steels complying with the requirements specified in **3.11** the maximum content of sulphur is to be 0.008*%* determined by the ladle analysis.

Table 3.2 Carbon Equivalent for Steels Produced by TMCP

Grade	Carbon Equivalent (%)
KA32, KD32, KE32, KF32	0.36max
KA36, KD36, KE36, KF36	0.38max
KA40, KD40, KE40, KF40	0.40max

Note:

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

Table 3.3 Heat Treatment [1]

Grade	Deoxidation Practice	Thickness *t* (*mm*)	Heat treatment [3]
KA	Any method except rimmed	$t \leq 50$	*AR* [4]
KB	Any method except rimmed	$t \leq 50$	
KD	Killed	$t \leq 25$	
	Killed and fine grain treated	$t \leq 35$	*AR* [4]
		$35 < t \leq 50$	*TMCP,N,CR*[5]
KE	Killed and fine grain treated	$t \leq 50$	*TMCP,N*[6]
*KA*32	Killed and fine grain treated (with *Nb* and/or *V*) [2]	$t \leq 12.5$	*AR* [4]
		$12.5 < t \leq 50$	*TMCP,N,CR*[5]
*KA*36	Killed and fine grain treated (without *Nb* and/or *V*) [2]	$t \leq 20$	*AR* [4]
		$20<t \leq 35$	*TMCP,N,CR*[7]
		$35<t \leq 50$	*TMCP,N,CR*[5]
*KD*32 *KD*36	Killed and fine grain treated (with *Nb* and/or *V*) [2]	$t \leq 12.5$	*AR* [4]
		$12.5 < t \leq 50$	*TMCP,N,CR*[5]
	Killed and fine grain treated (without *Nb* and/or *V*) [2]	$t \leq 20$	*AR* [4]
		$20<t \leq 25$	*TMCP,N,CR*[7]
		$25 < t \leq 50$	*TMCP,N,CR*[5]
*KE*32,*KE*36	Killed and fine grain treated	$t \leq 50$	*TMCP,N*[6]
*KA*40	Killed and fine grain treated	$t \leq 12.5$	*AR* [4]
		$12.5 < t \leq 50$	*TMCP,N,CR*
*KD*40	Killed and fine grain treated	$t \leq 50$	
*KE*40	Killed and fine grain treated	$t \leq 50$	*TMCP,N,QT*
*KF*32,*KF*36,*KF*40	Killed and fine grain treated	$t \leq 50$	*TMCP,N,QT*

Notes:

1 These conditions of heat treatment and size of lot for impact test are summarized in **Table 3.6**.

2 "*Nb* and/or *V*" stands for the addition of *Nb* and/or *V* either singly or in any combination, regardless of the specified minimum content, for grain refining, (ref., **Table 3.1 Note(9)**)

3 Indication symbols used in heat treatment are as follows (the same holds henceforth in this Chapter):

AR : As Rolled

CR : Controlled rolling

N : Normalising

TMCP : Thermo-Mechanical Controlled Processing

QT : Quenching and Tempering

4 *CR*, *N* or *TMCP* may be accepted.

5 Steel materials except steel plates (including steel flats not less than 600 *mm* in width) may be left as rolled, subject to the approval by the Society. (hereinafter in **3.1** referred to as *ARS*)

6 Steel materials except steel plates (including steel flats not less than 600 *mm* in width) may be treated according either to *ARS* or to controlled rolling, subject to the approval by the Society. (hereinafter in **3.1** referred to as *CRS*)

7 *ARS* may be accepted.

Table 3.4 Mechanical Properties

Grade	Tensile test			Impact test (1)		
	Yield point or proof stress (N/mm2)	Tensile strength (N/mm2)	Elongation (5) (L=5.65$\sqrt{A}$) (%)	Testing temperature (°C)	Minimum mean absorbed Energy (J)(3)	
					L	T
KA	235min	400-520	22min	-	-	-
KB				0(4)	27	20
KD				-20		
KE				-40		
KA32	315min	440-590	22min	0(2)	31	22
KD32				-20		
KE32				-40		
KF32				-60		
KA36	355min	490-620	21min	0(2)	34	24
KD36				-20		
KE36				-40		
KF36				-60		
KA40	390min	510-650	20min	0	39	26
KD40				-20		
KE40				-40		
KF40				-60		

Notes:

1 *L* (or *T*) denotes that the longitudinal axis of the test specimen is arranged parallel (or transverse) to the final direction of rolling (Refer to **3.1.7-3.(2)**).

2 Refer to **Note (1)** in **Table 3.6**.

3 When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified minimum mean absorbed energy or when the absorbed energy of a single test specimens is less in value than 70% of the specified minimum mean absorbed energy, the test is considered to be failed.

4 For steels up to 25 *mm* in thickness, generally no impact testing is required.

5 The minimum elongation for *U*1 test specimen is to be in compliance with the requirements given in **Table 3.5**.

Table 3.5 Minimum Elongation for *U*1 Specimen (%)

Grade	Thickness *t (mm)*							
	$t \leq 5$	$5< t \leq 10$	$10 <t\leq 15$	$15< t\leq 20$	$20<t\leq 25$	$25<t\leq 30$	$30<t\leq 40$	$40<t\leq 50$
KA,KB,KD,KE,KA32, KD32,KE32,KF32	14	16	17	18	19	20	21	22
KA36,KD36,KE36, KF36	13	15	16	17	18	19	20	21
KA40,KD40,KE40, KF40	12	14	15	16	17	18	19	20

Table 3.6 Size of Lot for Impact Test

Grade	Deoxidation practice	Products[3]	Heat treatment and size of lot impact test for [4] [6] (0 / 12.5 / 20 / 25 / 30 / 35 / 40 / 50)
KA	Any method except rimmed	All	*AR* (-)
KB		All	*AR* (50)
KD	Killed	All	*AR* (50)
	Killed and fine grain treated	Plates	TMCP (50),N (50),CR (50)
		Others	*AR* (50) / *TMCP* (50),*N* (50), *CR* (50), *ARS* (25)
KE	Killed and fine grain treated	Plates	*TMCP (P),N (P)*
		Others	*TMCP* (50),*N* (25), *CRS* (15)
*KA*32 *KA*36[1]	Killed and fine grain treated (with *Nb* and/or *V*) [2]	Plates	*AR* (50) / *TMCP* (50),*N* (50), *CR* (50)
		Others	*TMCP* (50),*N* (50), *CR* (50), *ARS* (25)
	Killed and fine grain treated (without *Nb* and/or *V*) [2]	Plates	*AR* (50) / *ARS* (25) / *TMCP* (50),*N* (50), *CR* (50)
		Others	*TMCP* (50),*N* (50), *CR* (50), *ARS* (25)
*KD*32 *KD*36	Killed and fine grain treated (with *Nb* and/or *V*) [2]	Plates	*AR* (50) / *TMCP* (50),*N* (50), *CR* (50)
		Others	*TMCP* (50),*N* (50), *CR* (50), *ARS* (25)
	Killed and fine grain treated (without *Nb* and/or *V*) [2]	Plates	*AR* (50) / *ARS* 25 / *TMCP* (50),*N* (50), *CR* (50)
		Others	*TMCP* (50),*N* (50), *CR* (50), *ARS* (25)
*KE*32 *KE*36	Killed and fine grain treated	Plates	*TMCP (P),N (P)*
		Others	*TMCP* (25),*N* (25), *CRS* (15)
*KA*40	Killed and fine grain treated	All	*AR* (50) / *TMCP* (50),*N* (50), *CR* (50)
*KD*40	Killed and fine grain treated	All	*TMCP* (50),*N* (50), *CR* (50)
*KE*40	Killed and fine grain treated	Plates	*TMCP* (P) , *N* (P), *QT* (PH)
		Others	*TMCP* (25) , *N* (25), *QT* (25)
*KF*32 *KF*36 *KF*40	Killed and fine grain treated	Plates	*TMCP* (P) , *N* (P), *QT* (PH)
		Others	*TMCP* (25) , *N* (25), *QT* (25)

Notes:

1 For grades *KA*32 and *KA*36 steels a relaxation in the size of lot may be permitted subject to the special approval of the Society.

2 Refer to **Note (2)** in **Table 3.3**.

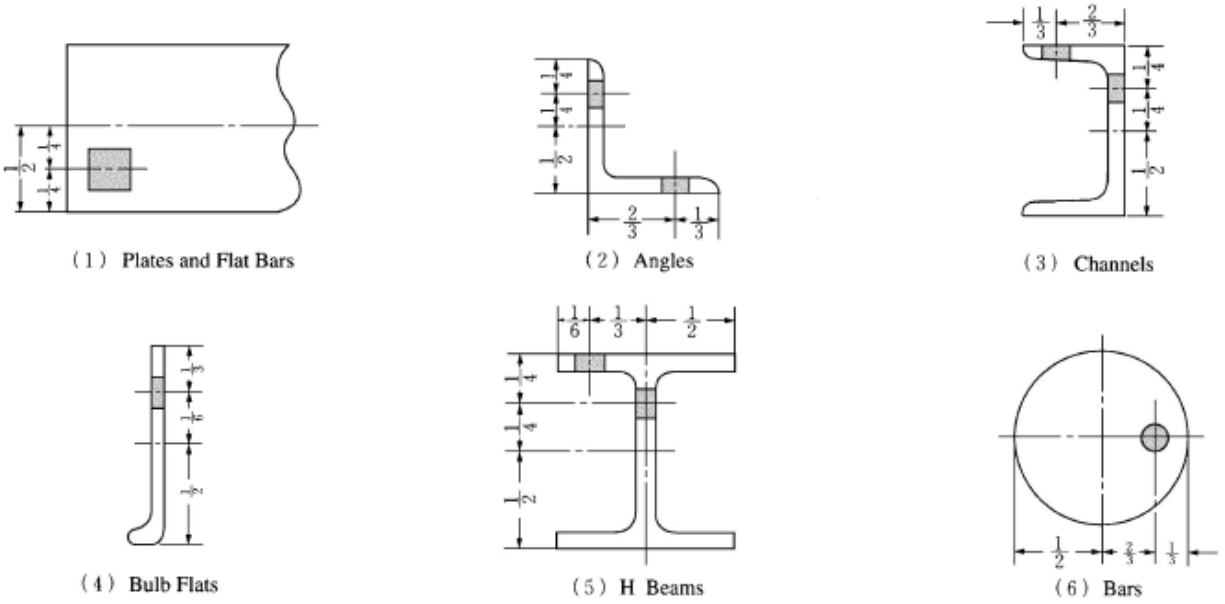
3 Steel plates include steel flats not less than 600 *mm* in width.

4 In the Table, marks put at the end of each symbol for heat treatment (*See* **Notes (3), (5)** and **(6)** of **Table 3.3**) stand for the volume of each lot. For examples, (50), (25) and (15) each indicate that steels not greater in mass than 50, 25 and 15 *ton* (belonging to the same charge in the same manufacturing process) are to be taken as one lot; (*P*) indicates that steel plate rolled directly from one slab or steel ingot (belonging to the same heat treatment condition) is to be taken as one lot; (*PH*) indicates that steel plate rolled directly from one slab or steel ingot and heat treated simultaneously in the same furnace including continuous furnace is to be taken as one lot; and (-)indicates that no impact test is required.

5 Refer to **Note (4)** in **Table 3.4**.

6 Steels, which have been subjected to *TMCP*, *N*, or *CR* instead of being left in a state of *AR* (refer to **Note (4)** in **Table 3.3**) are to be treated equivalent to those left in a state of *AR* with regard to the fundamental unit of lot .

Fig. 3.1 Selection of Test Samples



3.1.7 Selection of Test Specimens

1. In no case test specimens are to be heat treated separately from the product.

2. Tensile test specimens are to be taken according to **(1)** to **(3)** below.

(1) One test specimen is to be taken from one test sample.

(2) The test specimens are to be taken with their longitudinal axis normal to the final direction of rolling. For shapes, bars, and flat bars not exceeding 600 *mm* in width or when specially approved by the Society, however, they are to be taken with their longitudinal axis parallel to the final direction of rolling.

(3) Flat test specimens of full product thickness are, generally, to be used. Round test specimens, may be used when the product (except bars) thickness exceeds 40 *mm* or for bars. When round test specimens are taken from any steel except bars, they are to be taken at a portion approximately 1/4 of the thickness from the surface.

3. Impact test specimens are to be taken according to **(1)** to **(3)** below.

(1) A set of test specimens are to be taken from one test sample.

(2) The test specimens are to be taken with their longitudinal axis parallel (*L* direction) to the final direction of rolling. When deemed necessary by the Society, however, they are to be taken with their longitudinal axis normal (*T* direction) to the final direction of rolling.

(3) When the product thickness does not exceed 40 *mm*, the text specimens are to be cut with their edge within 2 *mm* from the as rolled surface. When the product thickness exceeds 40 *mm*, the test specimens are to be taken at a portion where the axis of the test specimen corresponds to approximately 1/4 of the thickness (1/6 of the diameter for bars) from the surface.

3.1.8 Surface Inspection and Verification of Dimensions

1. Surface inspection and verification of dimensions are the responsibility of the steel manufacturer.

2. The minus tolerance in the nominal thickness of plates is to be in compliance with the requirements specified in **Table 3.7**.

3. Any requirements regarding the minus tolerance except for the minus tolerance in the nominal thickness is left to the discretion of the Society.

Table 3.7 Verification of Dimensions

Products (1)	Minus tolerance (*mm*)
Steel Plates flat bars widths of 150 *mm or* greater	0.3 and under (2)
Others	At the discretion of the Society

Notes:

1 Steel plates are included flat bars of which width are not less than 150 *mm*.

2 The thickness is to be measured at random locations whose distance from a longitudinal edge shall be at least 10 *mm*.

However, local surface depressions resulting from imperfections (such as an affected part of shearing) and ground areas resulting from the elimination of defects may be disregarded.

3.1.9 Quality and Repair of Defects

1 The steel is to be reasonably free from segregations and non-metallic inclusions. The finished steel is to be free from internal or surface defects prejudicial to the use of steel for the intended application.

2 The surface defects may be removed by local grinding, provided that the thickness is in no place reduced to less than 93% of the nominal thickness, but in no case by more than 3 *mm*. Such local grindings are to be carried out in the presence of the Surveyor unless otherwise approved by the Society.

3 Surface defects which cannot be dealt with as above may be repaired by chipping or grinding followed by welding, subject to the approval by the Society, in the presence of the Surveyor unless otherwise approved by the Society, provided:

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

(2) That the welding is to be carried out by an approved procedure, by the welder qualified by the Society, with approved electrodes, and that welding is ground smooth to the correct nominal thickness;

(3) That subsequent to the finish grinding, the piece may be required to be normalized or otherwise heat treated at the Surveyor s discretion.

3.1.10 Additional Tests before Rejection

1. Where the tensile test from the first piece selected fails to meet the requirements, two further tensile tests may be made from the same piece. If both of these additional tests meet all of the requirements, the piece and the remaining pieces from the same lot may be accepted.

2. If one or both of the additional tests referred to above are unsatisfactory, the piece from which the above-mentioned test specimens have been taken is to be rejected.

However, the remaining pieces from the same lot may be accepted, provided that two of the remaining pieces in the lot, selected in the same way, are tested with satisfactory results.

3. Where the result of the impact test is unsatisfactory, additional tests may be carried out, with the exception of the following cases specified in **(1)** and **(2)** below, by taking a set of test specimens out of the same piece from which the above-mentioned test specimens have been taken. In this case, all pieces of the same lot from which the test specimens have been taken may be accepted, provided that the average absorbed energy of the six test specimens in all, including those which have been rejected as unsatisfactory, is not less than the required minimum mean absorbed energy, and that among the above six test specimens, whose absorbed energy is under the required minimum average absorbed energy, are less than two in number or test specimen, whose absorbed energy is under 70% of the required value, is less than one.

(1) The absorbed energy of all test specimens is under the required minimum average absorbed energy.

(2) The absorbed energy of two of the test specimens is under 70% the required minimum mean absorbed energy.

4. In case of **-3(1)** or **-3(2)** or where the first piece selected specified in **-3** is rejected, additional impact tests may be carried out on additional test specimens from each of two pieces largest in thickness selected further from the same lot. Where, in this case, each set of test specimens is in compliance with the requirements

respectively, these pieces and remaining pieces in the same lot may be accepted. If one or both of these additional sets of tests do not give satisfactory results, the pieces in the same lot are to be rejected.

5. Where the test specimens fail in the retests specified above, the piece from which the test specimens have been taken is to be rejected. However, at the manufacturer's option, the remaining pieces in the same lot may be resubmitted individually for test and those pieces which give satisfactory results may be accepted.

6. At the manufacturer's option, the rejected piece may be resubmitted after heat treatment or re-heat treatment, or may be resubmitted as any other grade of steel and then, may be accepted provided that the required tests are satisfactory.

3.1.11 Marking

Steels which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in 1.5.1.

3.2 Rolled Steel Plates for Boilers

3.2.1 Application

1. The requirements are to apply to the steel plates for boilers and pressure vessels to be used at high temperature (hereinafter referred to as "steel plates" in 3.2).

2. Steel plates having characteristics differing from those specified in 3.2 are to comply with the requirements in 1.1.1-2.

3.2.2 Kinds

The steel plates are classified into 5 grades as given in Table 3.8.

Table 3.8 Grades of Steel Plates

Grade	Application
*KP*42	Not more than 200mm in thickness
*KP*46	Not more than 200mm in thickness
*KP*49	Not more than 200mm in thickness
*KPA*46	Not more than 150mm in thickness
*KPA*49	Not more than 150mm in thickness

3.2.3 Chemical Composition

The chemical composition of the steel plates is to comply with the requirements given in Table 3.9.

Table 3.9 Chemical Composition

Grade	Thickness *t* (mm)	Chemical Composition (%)					
		C	*Si*	M_n	*P*	*S*	*Mo*
*KP*42	$t \leq 25$	0.24 max.	0.15-0.30	0.90 max	0.035 max	0.040 max	–
	$25 < t \leq 50$	0.27 max.					
	$50 < t \leq 200$	0.30 max.					
*KP*46	$t \leq 25$	0.28 max.	0.15-0.30	0.90 max	0.035 max	0.040 max	–
	$25 < t \leq 50$	0.31max.					
	$50 < t \leq 200$	0.33 max.					
*KP*49	$t \leq 25$	0.31 max.	0.15-0.30	0.90 max	0.035 max	0.040 max	–
	$25 < t \leq 50$	0.33 max.					
	$50 < t \leq 200$	0.35 max.					
*KPA*46	$t \leq 25$	0.18 max.	0.15-0.30	0.90 Max	0.035 Max	0.040 Max	0.45 -0.60
	$25 < t \leq 50$	0.21 max.					
	$50 < t \leq 100$	0.23 max.					
	$100 < t \leq 150$	0.25 max.					
*KPA*49	$t \leq 25$	0.20 max.	0.15-0.30	0.90 max	0.035 max	0.040 max	0.45 -0.60
	$25 < t \leq 50$	0.23 max.					
	$50 < t \leq 100$	0.25 max.					
	$100 < t \leq 150$	0.27 max					

Notes:

1 For *KP* 46, with 25 *mm* and over in thickness, carbon content and manganese content may be 0.3% or less and 1.00% or less respectively.

2 For *KP* 49, carbon content and manganese content may be 0.3% or less and 1.15% or less respectively.

3.2.4 Heat Treatment

1. For steel plates of the **"***KP***"** grade with 50 *mm* or less and of the "*KPA"* grade with 38 *mm* or less in thickness, they are to be as rolled. They, however, may be heat treated as case requires.

2. For steel plates of the "*KP"* grade more than 50 *mm* and of the "*KPA"* grade more than 38 *mm* in thickness, they are to be either normalized to obtain the normal grain size or heated uniformly to such a temperature at the time of hot forming that an effect equivalent to normalizing can be achieved. In case of normalizing, it is, in principle, to be performed by the manufacturer.

3. For steel plates to which stress relieving is required after welding or stress relieving is applied by the purchaser once or several times repeatedly during their working process, instruction of that effect is to be given at the time when they are placed for an order. In case where the procedure of stress relieving is not specified by the purchaser, a heat treatment is to be applied for the test coupons by heating them slowly and uniformly to the temperature of 600°C to 650°C, holding at that temperature for a period of over one hour per 25 *mm* of thickness, and then, to be cooled to 300°C in the furnace before exposure in a still atmosphere.

3.2.5 Mechanical Properties

The steel plates are to have the mechanical properties given in **Table 3.10**.

Table 3.10 Mechanical Properties

Grade	Yield Point (N/mm^2)	Tensile Strength (N/mm^2)	Elongation(%) ($L=5.65\sqrt{A}$)
*KP*42	225 min	410-550	24min
*KP*46	245 min	450-590	22min
*KP*49	265 min	480-620	20min
*KPA*46	255 min	450-590	23min
*KPA*49	275 min	480-620	21min

Note:

For the plates over 90 *mm* in thickness, the elongation may be reduced from that mentioned in the above Table by 0.5% for each increment of 12.5 *mm* or fraction there of exceeding 90 *mm* in thickness. Such reduction, however, is limited to 3%.

3.2.6 Selection of Test Samples

1. For the steel plates which are not to be heat treated, one test sample is to be taken from each plate as rolled directly from one slab or ingot ; for the plates which are to be heat treated, one test sample is to be taken from every similarly heat treated plate as rolled directly from one slab or ingot.

2. Where the plates specified in **-1** are stress-relieved as specified in **3.2.4-3**, the test samples are to be heat treated in accordance with the intended stress-relieving.

3. The test samples are to be taken from the portion approximately 1/4 of the width from the side end of the piece.

3.2.7 Selection of Test Specimens

Tensile test specimens are to be taken according to **(1)** to **(3)** below.

(1) One test specimen is to be taken from one test sample.

(2) The test specimens are to be taken with their longitudinal axis normal to the final direction of rolling.

(3) The test specimen of bar type is to be taken from the portion approximately 1/4 of the thickness of the surface.

3.2.8 Tolerance for Thickness

The minus tolerance for the nominal thickness of plates is to be 0.25 *mm* and under.

3.2.9 Additional Tests before Rejection

Where the tensile tests from the first test specimens selected fail to meet the requirements, additional tests may be conducted according to the requirements given in 1.4.4.

3.2.10 Marking for Accepted Steels

1. Steel plates which have satisfactorily complied with the required tests are to be marked with the identification mark relating to heat treatment in addition to the requirements in 1.5.1.

2. The marks relating to heat treatment in **-1** are to be as specified in the following;

Where the plates are normalized: *N*

Where the test specimens are heat treated corresponding to the stress relieving to be applied: *SR*

3.3 Rolled Steel Plates for Pressure Vessels

3.3.1 Application

The requirements are mainly to apply to the steel plates for pressure vessels to be used at atmospheric temperature (hereinafter referred to as steel plates in 3.3).

Steel plates having characteristic differing from those specified in 3.3 are to comply with the requirements in 1.1.1-2.

3.3.2 Kinds

The steel plates are classified into 6 grades as given in Table 3.11.

Table 3.11 Grades of Steel Plate

Grade	Application
*KPV*24	Not more than 200*mm* in thickness
*KPV*32	Not more than 150*mm* in thickness
*KPV*36	Not more than 150*mm* in thickness
*KPV*42	Not more than 150*mm* in thickness
*KPV*46	Not more than 75*mm* in thickness
*KPV*50	Not more than 75*mm* in thickness

3.3.3 Chemical Composition

1. The chemical composition of the steel plates is to comply with the requirements given in Table 3.12. When deemed necessary, chemical elements other than those given in the Table may be added.

2. Notwithstanding the requirement given in **-1**, when heat treatment has been conducted according to *TMCP*, the chemical composition of steel plates specified in Table 3.12 may be modified subject to the approval by the Society

Table 3.12 Chemical Composition

Grade	Chemical composition (%)						Carbon equivalent (%)	
	C		*Si*	*Mn*	*P*	*S*	50 *mm* and under in thickness	Over 50*mm* and up to 75*mm* in thickness
*KPV*24	100*mm* and under in thickness	0.18 max	0.15-0.35	1.40 max	0.30 max	0.30 max	--	--
	Over 100*mm* In thickness	0.20 max						
*KPV*32	0.18 max		0.15-0.55	1.60 max			--	--
*KPV*36	0.20 max		0.15-0.55				--	--
*KPV*42	0.18 max		0.15-0.75				--	--
*KPV*46	0.18 max		0.15-0.75				0.43 max	0.45 max
*KPV*50	0.18 max		0.15-0.75				0.44 max	0.46 max

3.3.4 Heat Treatment

1. *KPV*24, *KPV*32 and *KPV*36 plates are to be as rolled. They, however, may be controlled-rolled, *TMCP* or properly heat treated as case requires.

2. *KPV*42 plate is to be *TMCP*. But, they may be normalized or quenched and tempered subject to the approval by the Society. *TMCP* plate, however, may be manufactured up to 100 *mm* in thickness.

3. *KPV*46 and *KPV*50 plates are to be quenched and tempered. But, they may be normalized or *TMCP* subject to the approval by the Society.

4. In case of being normalized and quenched and tempered, they are, in principle, to be conducted by the manufacturer.

5. For steel plates to which stress relieving is required after welding or stress relieving is applied by the purchaser once or several times repeatedly during their working process, the requirements in **3.2.4-3** are to be applied.

3.3.5 Mechanical Properties

The steel plates are to have the mechanical properties given in **Table 3.13**

Table 3.13 Mechanical Properties

Grade	Tensile test					Impact test		
	Yied point or proof stress (N/mm^2)			Tensile strength (N/mm^2)	Elongation $L=5.65\sqrt{A}$ (%)	Testing temperature (°C)	Minimum mean absorbed energy (J)	Minimum Absorbed energy of individual test specimen (J)
	Thickness (mm)							
	$t\leq 50$	$50<t\leq 100$	$100<t\leq 200$					
*KPV*24	235min	215 min	195 min.	400 -510	23min.	0	47	27
KPV32	315 min	295 min	275 min (1)	490-610	22 min			
KPV36	355 min	335 min	315 min (1)	520-640	20 min			
KPV42	410 min	390 min	370 min (1)	550-670	18 min	-10		
KPV46	450 min	430 min(2)	–	570-700	17 min			
KPV50	490 min	470 min(2		610-740	16 min			

Notes:

1 For plate not more than 150 *mm* in thickness, this requirement is applied.

2 For plate not more than 75 *mm* in thickness, this requirement is applied.

3.3.6 Selection of Test Samples

1. For the steel plates which are not to be heat treated, one test sample is to be taken from each plate as rolled directly from one slab or ingot; for the steel plates which are to be heat treated, one test sample is to be taken from every similar heat treated plates as rolled directly from one slab or ingot.

2. Where the plates specified in **-1** are stress-relieved as specified in 3.3.4-5, test samples are to be heat treated in accordance with the intended stress-relieving.

3. The test samples are to be taken from the portion approximately 1/4 of the width from the side end of the piece.

3.3.7 Selection of Test Specimens

1. Tensile test specimens are to be taken according to **(1)** to **(3)** below.

(1) One test specimen is to be taken from one test sample.

(2) The test specimens are to be taken with their longitudinal axis normal to the final direction of rolling.

(3) When tensile test specimens of bar type are taken from any steel except bars, they are to be taken at portion approximately 1/4 of the thickness from the surface.

2. Impact test specimens are to be taken according to **(1)** to **(3)** below.

(1) A set of test specimens are to be taken from one test sample.

(2) The test specimens are to be taken with their longitudinal axis parallel (L direction) to the final direction of rolling. When deemed necessary by the Society, however, they are to be taken with their longitudinal axis normal (T direction) to the final direction of rolling.

(3) The test specimen is to be taken at a portion where the axis of the test specimen corresponds to approximately 1/4 of the thickness from the surface.

3.3.8 Surface Inspection and Verification of Dimensions

1. Surface inspection and verification of dimensions are the responsibility of the steel manufacturer.

2. The minus tolerance in the nominal thickness of plates is to be 0.25 *mm* and under.

3.3.9 Additional Tests before Rejection

1. Where the tensile test from the first test specimen selected fail to meet the requirements, additional tests may be conducted according to the requirements given in **1.4.4**.

2. In case where the mean value of absorbed energies in impact tests of 3 test specimens shows 85% or more of the specified value and each value of 2 or more test specimens meets the required value, although the mean value fails to meet the requirements, three additional test specimens may be put to retest taking such specimens from the position in the vicinity where the former test specimens were taken. In this case, if the mean value of 6 test specimens and each value of 3 test specimens in the retest meet the requirements, they may be accepted.

3.3.10 Marking

Steel plates which have satisfactorily complied with the required tests are to be marked with the identification mark relating to heat treatment in addition to the requirements in **1.5.1.**

The marks relating to heat treatment in **-1** are to be as specified in the following:

Where the plates are controlled-rolled: *CR*

Where the plates are heat treated by *TMCP*: *TMC*

Where the plates are normalized: *N*

Where the plates are quenched and tempered: *Q*

Where the test specimens are heat treated corresponding to the stress relieving to be applied: *SR*

3.3.11 Steel Plates equivalent to Standard

1. The mild steel plates of Grade *KD* and Grade *KE*, the high tensile steels of rolled steels for hull specified in **3.1** are taken as equivalent to the plates specified in **3.3**, in case where the test specimens are taken as required in **3.3.6** and **3.3.7** and test results are in compliance with the requirements in **3.1**. In this case, *PV* is to be suffixed to the markings to indicate the kind of plates specified in **3.1**.

2. Any requirements regarding heat treatment of steel plates specified in **-1** is left to the discretion of the Society.

3.4 Rolled Steels for Low Temperature Service

3.4.1 Application

1. The requirements are to apply to the rolled steels not exceeding 40 *mm* in thickness intended for tanks and ship's hull structures adjacent to tanks of liquefied gas carriers, and other parts such as hull structures of refrigerated cargo carrier which are exposed to low temperature (hereinafter referred to as steels in 3.4).
2. Any requirement regarding the steels over 40 *mm* in thickness is left to the discretion of the Society.
3. Steels having characteristics differing from those specified in 3.4 are to comply with requirements in 1.1.1-2.
4. The requirements provided in 3.1 are applicable except where specified in 3.4.

3.4.2 Kinds

The steels are classified into 10 grades as given in Table 3.14.

3.4.3 Deoxidation Practice and Chemical Composition

1. The deoxidation practice and chemical composition of each grade are to comply with the requirements given in Table 3.14. When deemed necessary, chemical elements other than those given in the table may be added to the option of the manufacturer.

2. Notwithstanding the requirement given in **-1.**, when heat treatment has been conducted according to *TMCP*, the chemical composition of steels specified in Table 3.14 may be modified subject to the approval by the Society.

Table 3.14 Grades and Chemical Composition

Grade	Deoxidation	Chemical composition (%)						Carbon equivalent (%)
		C	*Si*	*Mn*	*P*	*S*	*Ni*	
*KL*24A	Fully killed Aluminiun treated fine grain	0.16 max	0.10-0.50	0.70-1.60	0.030max	0.025max	--	0.41 max
*KL*24B		0.14 max						
*KL*27								
*KL*33								
*KL*37								
*KL*2*N*30			0.30 max	0.70max	0.025max	0.025max	2.10-2.50	--
*KL*3*N*32							3.25-3.75	
*KL*5*N*43		0.12 max		1.50max			4.75-6.00	
*KL*9*N*53		0.10 max		0.90max			8.50-9.50	
*KL*9*N*60								

3.4.4 Heat Treatment

The heat treatment of each grade is to comply with the requirements given in **Table 3.15**.

3.4.5 Mechanical Properties

1. The mechanical properties of steels are to comply with the requirements given in **Table 3.15**.
2. Where deemed necessary by the Society, other tests on notch toughness may be required.

Table 3.15 Heat Treatment and Mechanical Properties

Grade	Heat treatment	Tensile test			Impact test(4)(5)		
		Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (3) (L=5.65x$\sqrt{A}$) (%)	Testing(6) Temperature (°c)	Minimum mean absorbed Energy(J)	
						L	*T*
KL24A	Normalized or *TMCP*	235 min	400-510	20min	-40	41min	27 min
KL24B					-50		
KL27		265 min	420-540		-60		
KL33	Quenched and tempered or *TMCP*	325 min	440-560				
KL37		360min	490-610	19 min			
KL2N30	Normalized or normalized and tempered (1)(2)	295 min	420-570		-70		
KL3N32		315 min	440-590		-95		
KL5N43		420min	540-690		-110		
KL9N53	Double normalized and tempered(1)(2)	520min	690-830	18min	-196		
KL9N60	Quenched and tempered (1)(2)	590min			-196		

Notes:

1 If it is deemed appropriate by the Society, the intermediate heat treatment (the intermediate heat treatment is an operation of cooling from a dual phase composed of austenite and ferrite intended for improving toughness which is carried out prior to tempering) may be applied.

2 Heat treatment may be conducted according to *TMCP*, subject to the special approval by the Society.

3 The specified value for *U*1 test specimen other than those of proportional-size type is to be in compliance with the requirements given in **Table 3.16**.

4 *L* (or *T*) indicates that the longitudinal axis of the test specimen is arranged parallel (or transverse) to the final direction of rolling.

5 When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified minimum mean absorbed energy or when the absorbed energy of a single test specimen

is less in value than 70% of the specified minimum average absorbed energy, the test is considered to be failed.

6 Impact test temperature for steels specified in **IGC Code is** given in the **Table 3.17**.

Table 3.16 Minimum Elongation for U1 Specimen (%)

Grade	Thickness *t* (*mm*)							
	$t \leq 5$	$5<t\leq10$	$10<t\leq15$	$15<t\leq20$	$20<t\leq25$	$25<t\leq30$	$30<t\leq35$	$35<t\leq40$
KL24A, *KL24B*, *kL27*	13	14	15	16	17	18	18	18
KL33	12	13	14	15	16	17	18	19
KL37	11	12	13	14	15	16	17	18
KL2N30, *KL3N32*, *KL5N43*	12	13	14	15	16	17	17	18
KL9N53, *KL9N60*	10	11	12	13	14	15	16	17

Table 3.17 Impact Teat Temperature of Steels Specified in IGC Code

Grade	Thickness	Testing temperature (°C)(1)
KL24A	$t\leq 25$	-20 or (T_D-5) (2)
KL24B	$25<t\leq30$	-20 or (T_D-10) (2)
KL27	$30<t\leq35$	-20 or (T_D-15) (2)
KL33 , KL37	$35<t\leq40$	(T_D-20) (2)
KL2N30	$t\leq 25$	-70
	$25<t\leq30$	-70 or (T_D-10) (2)
	$30<t\leq35$	-70 or (T_D-15) (2)
	$35<t\leq40$	-70 or (T_D-20) (2)
KL3N32	$t\leq 25$	-95
	$25<t\leq30$	-95 or (T_D-10) (2)
	$30<t\leq35$	-95 or (T_D-15) (2)
	$35<t\leq40$	-95 or (T_D-20) (2)
KL5N43	$t\leq 25$	-110
	$25<t\leq30$	-110 or (T_D-10) (2)
	$30<t\leq35$	-110 or (T_D-15) (2)
	$35<t\leq40$	-110 or (T_D-20) (2)
KL9N53	$t\leq 40$	-196
KL9N60		

Notes:

1 T_D is the design temperature (°C).

2 The testing temperature is to be the lower of those specified above.

3.4.6 Selection of Test Samples

For steel plates, one test sample is to be taken from each plate which is rolled directly from one slab or ingot and is simultaneously heat treated in the same furnace including continuous furnace. When *TMCP* is used as heat treatment, one test sample is to be taken from each plate which is rolled directly from one slab or ingot.

For test samples used in other steels than steel plates, steels not greater in weight than 10 *tonnes* (having the same cross-sectional dimensions and being from the same cast manufactured by the same process) are to be treated as one lot, and one test sample is to be taken from each lot.

The requirements specified in **3.1.6-4** are to be applied to the selection of the test samples.

3.4.7 Selection of Test Specimens

1. Tensile test specimens are to be taken according to the requirements specified in **3.1.7**.

2. Impact test specimens are to be taken according to the following **(1)** and **(2)**:

(1) The requirement specified in **3.1.7-3(1)** and **(3)** are to apply.

(2) For steel plates, the test specimens are to be taken with their longitudinal axis normal (*T* direction) to the final direction of rolling; for other steels than steel plates, they are to be taken with their longitudinal axis parallel (*L* direction) to the final direction of rolling.

3.4.8 Surface Inspection and Verification of Dimensions

1. Surface inspection and verification of dimensions are the responsibility of the steel manufacturer.

2. The minus tolerance in the nominal thickness of plates is to be 0.25 *mm* and under.

3. For steels other than plates, any requirement regarding the minus tolerance is left to the discretion of the Society.

3.4.9 Additional Tests before Rejection

Where the tensile test from the first piece selected fails to meet the requirements, additional test may be conducted according to the requirements given in **1.4.4**.

Regarding the impact test, additional tests may be conducted according to the requirements given in **3.1.10-3**.

3.4.10 Marking

Steels which have satisfactorily complied with the required test are to be marked with identification mark in accordance with the requirements in **1.5.1**. For steels to which the requirements given in **Note (6)** to **Table 3.15** have been applied, the impact testing temperature and "*T*" are to be suffixed to the markings. (Example: *KL*33-50*T*)

3.5 Rolled Stainless Steels

3.5.1 Application

1. The requirements are to apply to the rolled stainless steels for tanks in low temperature service or corrosion-resisting service (hereinafter referred to as steels in 3.5).

2. Where deemed necessary by the Society, steel bars specified in this Section may be used for propeller shafts and so on.

3. Steels having characteristics differing from those specified in 3.5 are to comply with the requirements in 1.1.1-2.

4. The requirements provided in 3.1 are applicable except where otherwise specified in 3.5.

3.5.2 Kinds

The steels are classified into 16 grades as given in Table 3.18.

3.5.3 Chemical Composition

The chemical composition of the steels is to comply with the requirements given in Table 3.18.

Table 3.18 Grades and Chemical Composition of Stainless Steels

Grade	Chemical composition (%)									
	C	*Si*	*Mn*	*P*	*S*	*Ni*	*Cr*	*Mo*	*N*	Others
*KSUS*304	0.08max	1.00max	2.00 max	0.045 max	0.030 max	8.00-10.50	18.00-20.00	–	–	–
*KSUS*304*L*	0.030max					9.00-13.00				
*KSUS*304*N*1	0.08max		2.5 max			7.00-10.50			0.10-0.25	
*KSUS*304*N*2						7.50-10.50			0.15-0.30	*Nb*≤0.15
*KSUS*304*LN*	0.030max		2.00 max			8.50-11.50	17.00-19.00		0.12-0.22	–
*KSUS*309*S*	0.08max					12.00-15.00	22.00-24.00		–	
*KSUS*310*S*		1.50max				19.00-22.00	24.00-26.00			
*KSUS*316		1.00max				10.00-14.00	16.00-18.00	2.00-3.00		
*KSUS*316*L*	0.030max					10.00-14.00			0.10-0.22	
*KSUS*316*N*	0.08max					10.00-14.00				
*KSUS*316*LN*	0.030max					10.50-14.50	16.50-18.50		0.12-0.22	
*KSUS*317	0.08max					11.00-1500	18.00-20.00	3.00-4.00	–	
*KSUS*317*L*	0.030max								0.10-0.22	
*KSUS*317*LN*										
*KSUS*321	0.08max					9.00-13.00	17.00-19.00	–	–	*Ti*≥5xC
*KSUS*329*J*1	0.08max	1.00max	1.50 max	0.040 max	0.030 max	3.00-6.00	23.00-28.00	1.00-3.00	–	–
*KSUS*329*J*3*L*	0.030max	1.00max	2.00max	0.040max	0.030 max	4.50-6.50	21.00-24.00	2.50-3.50	0.08-0.20	–
*KSUS*329*J*4*L*	0.030max	1.00max	1.50 max	0.040 max	0.030 max	5.50-7.50	24.00-26.00	2.50-3.50	0.08-0.30	–
*KSUS*347	0.08max	1.00max	2.00 max	0.045 max	0.030 max	9.00-13.00	17.00-19.00	–	–	*Nb*≥10xC

3.5.4 Heat Treatment

The steels are generally to a solid solution treatment.

3.5.5 Mechanical Properties

1. The mechanical properties of steels are to comply with the requirements given in Table 3.19. However, the specified value of the minimum proof stress may be altered to other values subject to the approval of the Society.

2. The hardness in hardness tests, according to the test methods, is to comply with the requirements given in Table 3.19.

3. Where deemed necessary by the Society, impact tests may be required.

Table 3.19 Mechanical Properties of Stainless Steels

Grade	Tensile test			Hardness test		
	Proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (L=5.65x$\sqrt{A}$) (%)	H_B	H_{RB}	H_V
*KSUS*304	205min	520min	40min	187max	90max	200max
*KSUS*304*L*	175min	480min				
*KSUS*304*N*1	275min	550min	35min	217max	95max	220max
*KSUS*304*N*2	345min	690min		248max	100max	260max
*KSUS*304*LN*	245min	550min	40min	217max	95max	220max
*KSUS*309*S*	205min	520min		187max	90max	200max
*KSUS*310*S*						
*KSUS*316						
*KSUS*316*L*	175min	480min				
*KSUS*316*N*	275min	550min	35min	217max	95max	220max
*KSUS*316*LN*	245min		40min			
*KSUS*317	205min	520min		187max	90max	200max
*KSUS*317*L*	175min	480min				
*KSUS*317*LN*	245min	550min		217max	95max	220max
*KSUS*321	205min	520min		187max	90max	200max
*KSUS*329*J*1	390min	590min	18min	277max	29max (1)	292max
*KSUS*329*J*3*L*	450min	620min	18min	302max	32max (1)	320max
*KSUS*329*J*4*L*	450min	620min	18min	302max	32max (1)	320max
*KSUS*347	205min	520min	40min	187max	90max	200max

Note:

1 Rockwell hardness of *KSUS*329*J*1, *KSUS*329*J3L* and *KSUS*329*J4L* is to *C* scale value (H_{RC}).

3.5.6 Other Properties

Where deemed necessary by the Society according to the use of steels, tests on corrosion resistance may be required.

3.5.7 Selection of Test Samples

1. One test sample is to be taken from each steel as rolled directly from one slab or ingot.

2. The requirements provided in **3.1.6-4.** are to be applied to the selection of the test samples.

3.5.8 Selection of Test Specimens

1. Tensile test specimens are to be taken according to the requirements specified in **3.1.7-2**.

The hardness test specimen may be a portion of tensile test specimen.

3.5.9 Surface Inspection and Verification of Dimensions

1. Surface inspection and verification of dimensions are the responsibility of the steel manufacturer.

2. The minus tolerance in the nominal thickness of plates is to be 0.25 *mm* and under.

3. For steels other than plates, any requirement regarding the minus tolerance is left to the discretion of the Society.

3.5.10 Marking

1. Steels which have satisfactorily complied with the required tests are to be marked with identification mark in accordance with the requirements in **1.5.1**.

2. For steels complying with the requirement in **3.5.1-2**, -"*SU"* is to be suffixed to the grade mark of the steel bars. (*ex*. *KSUS*304-SU)

3. For steels to which the provisory requirement in **3.5.5-1** is applicable, the specified value of proof stress and "*M"* are to be suffixed to the grade mark. (*e.g. KSUS*304-235*M).*

3.6 Round Bars for Chains

3.6.1 Application

1. The requirements are to apply to the rolled steel round bars for chains specified in **Part 5** (hereinafter referred to as "chain bars" in **3.6**).

2. Chain bars having characteristic differing from those specified in **3.6** are to comply with the requirements in **1.1.1-2**.

3. The requirements provided in **3.1** are applicable except where specified in **3.6**.

3.6.2 Kinds

The chain bars are classified into 6 grades as given in Table 3.20.

Table 3.20 Grades of Chain Bars

Grade		Application
Grade 1 chain bar	*KSBC*31	Studless chain, Grade 1 chain
Grade 2 chain bar	*KSBC*50	Grade 2 chain
Grade 3 chain bar	*KSBC*70	Grade 3 chain
Grade *R*3 chain bar	*KSBCR*3	Grade *R*3 chain
Grade *R*3*S* chain bar	*KSBCR3S*	Grade *R*3*S* chain
Grade *R*4 chain bar	*KSBCR4*	Grade *R*4 chain
Grade *R*4S chain bar	*KSBCR4S*	Grade *R*4*S* chain
Grade *R*5 chain bar	*KSBCR5*	Grade *R*5 chain

3.6.3 Deoxidation Practice and Chemical Composition

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in Table 3.21. Elements other than specified in Table 3.21 may be added subject to a special approval by the Society.

Table 3.21 Deoxidation Practice and Chemical Composition (%)

Grade	Deoxidation	*C*	*Si*	*Mn*	*P*	*S*	$Al_{(1)}$
*KSBC*31	Killed	0.20max	0.15-0.35	0.40min	0.040max	0.040max	_
*KSBC*50	Fine grained Killed	0.24max	0.15-0.55	1.60max	0.035max	0.035max	0.020min
*KSBC*70		0.36max	0.15-0.55	1.00-1.90	0.035max	0.035max	0.020min
*KSBCR*3 *KSBCR*3*S* *KSBCR*4 *KSBCR*4*S* *KSBCR*5	Fine grained Killed	Detailed chemical composition is to be approved by the Society. For Grade *KSBCR*4, *KSBCR*4*S* and *KSBCR*5 the steel should a minimum of 0.2% molybdenum.					

Note:

1 Al content is to be represented by the total *Al* content and may be replaced partly other fine graining elements.

3.6.4 Mechanical Properties

The mechanical properties of steel bars are to comply with the requirements given in Table 3.22.

Table 3.22 Mechanical Properties

Grade	Tensile test			Impact test		
	Yield point or proof stress[3] (N/mm^2)	Tensile strength[3] (N/mm^2)	Elongation (L=5d) (%)	Reduction of área (%)	Testing temperatura (°C)	Minimum mean absorbed energy (J)
*KSBC*31	_	370-490[4]	25 min	_	_	_
*KSBC*50	295 min	490-690	22 min	_	0	27
*KSBC*70	410 min	690 min	17 min	40 min	0	60
*KSBCR*3	410 min	690 min	17 min	50 min	-20[5]	40[5]
*KSBCR*3*S*	490 min	770 min	15 min	50 min	-20[5]	45[5]
*KSBCR*4	580 min	860 min	12 min	50 min	-20	50
*KSBCR*4*S*	700 min	960 min	12 min	50 min	-20	56
*KSBCR*5	760min	1000 min	12 min	50 min	-20	58

Notes:

1 When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified minimum mean absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified minimum mean absorbed energy, the test is considered to have failed.

2 For *KSBC*50 intended for Grade 2 chain which will be heat-treated according to the provision **3.1.5 of Part 5**, no impact testing is required.

3 Aim value of yield to tensile ratio for grades *KSBCR*3, *KSBCR*3*S, KSBCR*4, *KSBCR*4S and *KSBCR*5 is to be maximum 0.92.

4 Lower limit of tensile strength of grade *KSBC*31 may be 300N/mm^2 with the approval of the Society.

5 Impact test of grade *KSBCR*3 and *KSBCR*3*S* may be carried out at the temperature 0 °C where approved by the Society. In this case, minimum mean absorbed energy is to be not less than 60 *J* for grade *KSBCR*3 and 65 *J* for grade *KSBCR*3*S*.

3.6.5 Selection of Test Samples

1. Steel bars not greater in weight than 50 *tonnes* (from the same cast manufactured by the same process) are to be treated as one lot, and one test sample largest in diameter is to be taken from each lot.

2. The heat treatment of the test samples is to comply with the requirements given in **Table 3.23** for each grade.

In this case, the same heat treatment applied to chain bars after welding is to be carried out on the test sample.

Table 3.23 Heat Treatment of Test Sample

Grade	Heat treatment
*KSBC*31	As rolled or Normalized (1)
*KSBC*50	As rolled or Normalized (1)
*KSBC*70, *KSBCR*3, *KSBCR*3*S*, *KSBCR*4, *KSBCR*4*S*, *KSBCR*5	Normalized, Normalized and tempered, or Quenched and tempered

Note:

1 The round bars for chains which will not be heat treated according to the provision **3.1.5 of Part 5** are to be treated as rolled.

3.6.6 Selection of Test Specimens

1. Test specimens are to be taken in accordance with **Table 3.24** from test samples specified in **3.6.5**.

2. For grades *KSBCR*3*S* and *KSBCR*4, *KSBCR*4S and *KSBCR*5 in addition to the test specimen required by **-1**, two tensile test specimens having diameter of 20 *mm* in principle are to be taken the hydrogen embrittlement test. In this case, test specimen is to be taken from the central region of bar materials which have been simulated heat treated shown as **(1)** or **(2)**.

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

(2) In case of ingot casting, test samples representing two different ingots are to be taken.

3. The test specimens are to be taken with their longitudinal axis parallel to the final direction of rolling.

4. The tensile and impact test specimens are to be taken from the test sample in the longitudinal direction at a depth of 1/6 diameter from the surface or as close as possible to this position (See **Fig. 3.2**).

5. The longitudinal axis of the notch is to correspond approximately to the radial direction of each test specimen.

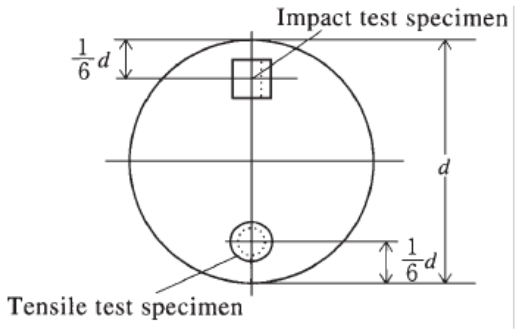
Table 3.24 Number of Test Specimens

Grade	Number of tensile test specimens	Number of impact test specimens
*KSBC*31	1 piece	_
*KSBC*50	1 piece	1 set (3 pieces)(1)
*KSBC*70, *KSBCR*3, *KSBCR*3*S*, *KSBCR*4, *KSBCR*4S, *KSBCR*5	1 piece	1 set (3 pieces)

Note:

1 In case where **Note (2)** of **Table 3.22** is applied, no impact test specimen need to be taken.

Fig. 3.2 Selection of Test Specimens



3.6.7 Hydrogen Embrittlement Test

1. Hydrogen embrittlement test is to be carried out in accordance with the following procedure.

(1) One specimen is to be tested within max. 3 *hours* after machining or the specimen may be cooled to -60°C immediately after machining and kept at that temperature for a period of max. 5 *days*.

(2) The other specimen is to be tested after baking at 250°C for 4 *hours*.

(3) A slow strain rate as far as practicable (strain rate less than 0.0003 s^{-1}) is used during the entire test, and tensile strength, elongation and reduction of area are to be measured.

2. The test result is to be complied with the following formula.

$$Z_{(1)} / Z_{(2)} \geq 0.85$$

$Z_{(1)}$ is the reduction of area measured by the test specified in **-1(1)**

$Z_{(2)}$ is the reduction of area measured by the test specified in **-1(2)**

3.6.8 Surface Inspection, Non-destructive Test and Verification of Dimentions

1. Surface inspection for all grades is to be carried out it is to be confirmed that there is no harmful defect.

2. For grades *KSBCR*3, *KSBCR*3*S, KSBCR*4, *KSBCR*4S and *KSBCR*5 all bar materials are subjected to ultrasonic examination at an appropriate stage of the manufacture and it is to be confirmed that there is no harmful defect.

3. For grades *KSBCR*3, *KSBCR*3*S* and *KSBCR*4, *KSBCR*4S and *KSBCR*5, one hundred persent of bar material is to be examined by magnetic particle or eddy current methods and it is to be confirmed that there is no harmful defect.

4. Notwithstanding the requirements of **-2** and **-3**, the frequency of non-destructive test may be reduced where approved by the Society considering quality control of manufacturer is consistently achieved. However, non-destructive test to the test samples required by **3.6.5** is to be carried out in any case.

5. Dimensional tolerance of round bars refers to **Table 3.25**.

Table 3.25 Dimensional Tolerance

Nominal diameter (mm) (1)	Tolerance on diameter (mm)	Tolerance on roundness (d_{max}-d_{min}) (mm^2)
d<25	-0 ~ +1.0	0.60 max
25 ≤ d ≤ 35	-0 ~ +1.2	0.80 max
36 ≤ d ≤ 50	-0 ~ +1.6	1.10 max
51 ≤ d ≤ 80	-0 ~ +2.0	1.50 max
81 ≤ d ≤ 100	-0 ~ +2.6	1.95 max
101 ≤ d ≤ 120	-0 ~ +3.0	2.25 max
121 ≤ d ≤ 160	-0 ~ +4.0	3.00 max
161 ≤ d ≤ 210	-0 ~ +5.0	4.00 max

Notes:

1 For bar materials of nominal diameter which has more than 211mm, dimensional tolerance is to be as deemed appropriate by the Society.

2 d_{max}. and $d_{min.}$ are the maximum and minimum diameter of a single bar material.

3.6.9 Additional Tests before Rejection

1. Where the tensile test or impact test on the selected first test specimens have failed to meet the requirements, additional tests may be carried out according to the requirements given in **3.1.10-1** or **-3**.

2. Where the test of heat treated samples has failed, additional tests may be carried out according to the requirements given in **1.4.4-3.**

3. Where the hydrogen embrittlement test selected for the first test specimen has failed to meet the requirements specified in **3.6.7-2**, the bar materials may be subjected to a hydrogen degassing treatment after approved by the Society, and additional test can be performed after degassing.

3.6.10 Marking

Chain bars which have proved satisfactory compliance with the required tests are to be marked with identification marks in accordance with the requirements in **1.5.1**.

3.7 Rolled Steel Bars for Machine Structures

3.7.1 Application

1. The requirements are to apply to the rolled steel bars used for machine structures such as shafts or bolts (hereinafter referred to as steel bars in **3.7**).

2. Steel bars having characteristics differing from those specified in **3.7** are to comply with the requirements in **1.1.1-2**.

3.7.2 Kinds

The steel bars are classified into 2 grades as given in Table 3.26.

Table 3.26 Grades of Steel Bars

Kind	Grade
Rolled carbón Steel bars	The grade of Steel bars is to be indicated by suffixing a letter "R" to the grade "KSF" specified in Table 6.3 (ex. KSFR41)
Rolled low alloy Steel bars	The grade of Steel bars is to be indicated by suffixing a letter "R" to the grade "KSFA" specified in Table 6.3 (ex. KSFR60)

3.7.3 Deoxidation Practice and Chemical Composition

1. Deoxidation practice for steel bars is to be killed.

2. Chemical composition of steel bars is to comply with the requirements given in 6.1.4. In application, the terms "steel forgings" are to be read as steel bars.

3.7.4 Reduction Ratio and Heat Treatment

1. The reduction ratio of steel bars is to be not less than 6 unless specially approved by the Society.

2. The heat treatment of steel bars is to be as deemed appropriate by the Society.

3.7.5 Mechanical Properties

1. Mechanical properties of steel bars are to comply with the requirements given in 6.1.6-1 and **-2**. In application, the term "steel forgings" is to be read as "steel bars".

3.7.6 Selection of Test Samples

For the test samples, steel bars not greater in mass than 5 *tons* (belonging to the same diameter from the same manufacturing process in the same charge) are to be treated as one lot, and one sample is to be selected each lot.

3.7.7 Selection of Test Specimens

Test specimens are to be taken according to **(1)** and **(2)** below:

(1) One tensile test specimen is to be taken from one test sample.

(2) The requirements specified in 3.6.6-3 and **-**4 are to apply.

3.7.8 Surface Inspection and Verification of Dimensions

1. Surface inspection and verification of dimensions are the responsibility of the steel bars manufacturer.

2. For steel bars, the verification of dimensions is left to the discretion of the Society.

3.7.9 Non-destructive Test

Non-destructive test of steel bars is to comply with the requirements given in **6.1.10.** In application, the terms **"**steel forgings" are to be read as "steel bars".

3.7.10 Repair of Defects

Repair of defects is to comply with the requirements given in **6.1.11**. In application, the term "steel forgings" is to be read as "steel bars".

3.7.11 Additional Tests before Rejection

Where the tensile test or the hardness test from the first test specimen selected fails to meet the requirements, additional tests may be conducted according to the requirements given in **1.4.4**.

3.7.12 Marking

Steel bars which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **1.5.1**. For steel bars to which the requirements given in **6.1.6-2** have been applied, the value corresponding to the required tensile strength employed is to be used to the grade mark. (ex. Where the required tensile strength employed is 460 N/mm^2, "*KSFR*47" is to be indicated)

3.8 High Strength Quenched and Tempered Rolled Steel Plates for Structures

3.8.1 Application

1. The requirements given in **3.8** are to apply to the high strength quenched and tempered rolled steels for structures not exceeding 70 *mm* in thickness intended for mobile offshore units, tanks of liquefied gas carriers and process pressure vessels (hereinafter referred to as "steels" in **3.8**).

2. The requirements other than those specified in section **3.8** are to apply to **3.1**.

3. Any requirements regarding the steels over 70 *mm* in thickness are left to the discretion of the Society.

4. Steel plates having characteristics differing from those specified in **3.8** are to comply with the requirements in **1.1.1-2**.

3.8.2 Kinds

The steel plates are classified into the grades as given in **Table 3.27**

Table 3.27 Grades, Deoxidation Practice and Chemical Composition of Steels

Grade	Deoxidation practice	Chemical composition (%)												Cold cracking Susceptibility (%) Thickness t (*mm*)	
		C	*Si*	*Mn*	*P*	*S*[1]	*Cu*	*Ni*	*Cr*	*Mo*	*V*	*B*	*N*	$t \leq 50$	$50 < t \leq 70$
*KA*420	Fully killed and fine grain treated	0.21 max.	0.55 max.	1.70 max.	0.035 max.	0.035 max.	These elements may be added when necessary subject to approval of the Society						0.020 max.	0.25 max.	0.27 max
*KD*420 *KE*240		0.20 max.			0.030 max.	0.030 max.									
*KF*420		0.18 max.		1.60 max.	0.025 max	0.025 max.									
*KA*460		0.21 max.	0.55 max.	1.70 max.	0.035 max.	0.035 max.								0.26 max.	0.28 max.
*KD*460 *KE*460		0.20 max.			0.030 max	0.030 max.									
*KF*460		0.18 max.		1.60 max.	0.025 max.	0.025 max.									
*KA*500		0.21 max	0.55 max.	1.70 max.	0.035 max.	0.035 max.								0.26 max.	0.28 max.
*KD*500 *KE*500		0.20 max.			0.030 max.	0.030 max.									
*KF*550		0.18 max		1.60 max.	0.025 max.	0.025 max.									
*KA*620		0.21 max	0.55 max.	1.70 max.	0.035 max.	0.035 max.	0.50 max.	-	1.00 max	0.60 max	0.10 max	0.006 max	0.020 max	0.29 max	0.31 max.
*KD*620 *KE*620		0.20			0.030 max.	0.030 max.									
*KF*620		0.18 max.		1.60 max.	0.025 max.	0.025 max.									
*KA*620*N*		0.21 max.	0.55 max.	1.70 max.	0.035 max.	0.035 max.		0.30∽ 1.30	0.70 max						
*KD*620*N* *KE*620*N*		0.20 max.			0.030 max.	0.030 max.									
*KF*620*N*		0.18 max.		1.60 max.	0.025 max.	0.025 max.		0.30∽ 2.00							
*KA*690		0.21 max	0.55 max.	1.70 max.	0.035 max.	0.035 max.		-	1.20 max					0.30 max.	0.32 max.
*KD*690 *KE690*		0.20 max.			0.030 max.	0.030 max.									
*KF*690		0.18 max.		1.60 max.	0.025 max.	0.025 max.									
*KA*690*N*		0.21 max.	0.55 max.	1.70 max.	0.035 max.	0.035 max.		0.30∽ 1.50	0.80 max						
*KD*690*N* *KE*690*N*		0.20 max.			0.030 max.	0.030 max.									
KF690*N*		0.18 max.		1.60 max	0.025 max.	0.025 max.		0.30∽ 2.20							

Note:

1 For steels complying with the requirements specified in 3.11 the maximum content of sulphur is to be 0.008% determined by the ladle analysis.

3.8.3 Deoxidation Practice and Chemical Composition

1. The deoxidation practice and chemical composition of steels are to comply with the requirements given in Table 3.27. Where subjected to the approval of the Society, other elements than specified in the Table may be added at the option of the manufacturer.

2. Notwithstanding the requirements given in **-1**, where heat treatment has been conducted according to *TMCP*, the requirement on the chemical composition of the steel may be modified subject to the special approval by the Society.

3.8.4 Heat Treatment

The heat treatment of each grade is to comply with the requirements given in Table 3.28.

3.8.5 Mechanical Properties

1. The steels are to conform to the requirements given in Table 3.28. as to mechanical properties. The application of requirements differing from those given above may be allowed, subject to the special approval by the Society.

2. Where deemed necessary by the Society, other tests on notch-toughness and weldability may be required in addition to the tests specified in **-1**.

3.8.6 Selection of Test Samples

1. One test sample is to be taken from each steel which is rolled directly from one slab, ingot, etc. and is simultaneously heat treated in the same furnace including continuous furnace. When *TMCP* is used as heat treatment, one test sample is to be taken from each steel which is rolled directly from one slab, ingot, etc.

2. The requirements specified in 3.1.6-4 are to be applied to the selection of the test samples.

3.8.7 Selection of Test Specimens

1. Tensile test specimens are to be taken according to the requirements specified in 3.1.7-2.

2. Impact test specimens are to be taken according to the requirements specified in 3.4.7-2.

3.8.8 Surface Inspection and Verification of Dimensions

The requirements specified in 3.1.8 are to apply to surface inspection and verification of dimensions are to be specified in 3.1.8.

3.8.9 Additional Tests before Rejection

1. Where the tensile test from the first test specimen selected fails to meet the requirements, additional tests may be conducted according to the requirements given in 3.1.10-1.

2. Regarding the impact tests, additional tests are to be carried out according to the requirements given in 3.1.10-3.

3.8.10 Marking

Steel plates which have satisfactorily complied with the required tests are to be marked with identification mark in accordance with the requirements in 1.5.1 and in addition the followings **(1)** and **(2)**:

(1) For steels to which the requirements given in the provision to 3.8.5-1 have been applied, *-M* is to be suffixed to the marking (Example: *KA*620-*M*).

(2) For steels to which the requirements given in Note (5) to Table 3.28 have been applied, *-PV* is to be suffixed to the marking (Example: *KA*620-*PV*).

Table 3.28 Heat Treatment and Mechanical Properties

Grade	Heat treatment	Tensile test				Impact test (3)(4)(5)	
		Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation $(L = 5.65\sqrt{A})(\%)$ (2)	Testing temperature (°C)	Minimum mean absorbed energy (*J*)	
						L	*T*
*KA*420	Quenched and tempered (1)	420min.	530~680	18min.	0	42	28
*KD*420					-20		
*KE*420					-40		
*KF*420					-60		
*KA*460		460min	570~720	17min.	0	46	31
*KD*460					-20		
*KE*460					-40		
*KF*460					-60		
*KA*500		500min	610~770	16min.	0	50	33
*KD*500					-20		
*KE*500					-40		
*KF*500					-60		
*KA*550		550min	670~830	16min.	0	55	37
*KD*550					-20		
*KE*550					-40		
*KF*550					-60		
*KA*620 *KA*620*N*		620min	720 ~890	15min.	0	62	41
*KD*620 *KD*620*N*					-20		
*KE*620 *KE*620*N*					-40		
*KF*620 *KF*620*N*					-60		
KA690 *KA690N*		690min	770 ~ 940	14min.	0	69	46
KD690 *KD690N*					-20		
KE690 *KE690N*					-40		
KF690 *KF690N*					-60		

Notes:

1 Heat treatment may be conducted according to *TMCP*, instead of quenching and tempering, subject to the approval by the Society.

2 The minimum elongation for *U*1 test specimen is to be in compliance with requirements given in **Table 3.29**.

3 *L* (or *T*) denotes that the longitudinal axis of the test specimen is arranged parallel (or transverse) to the final direction of rolling.

4 When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified minimum mean absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified minimum mean absorbed energy, the test is considered to be failed

5 Impact test for steels specified in *IGC Code IMO* is given in **Table 3.30**.

Table 3.29 Minimum Elongation for *U*1 Specimen (%)

Grade	Thickness *t* (*mm*)						
	$t \leq 10$	$10 < t \leq 15$	$15 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 40$	$40 < t \leq 50$	$50 < t \leq 70$
*KA*420, *KD*420, *KE*420, *KF*420	11	13	14	15	16	17	18
KA460, *KD460* , *KE460* , *KF460*	11	12	13	14	15	16	17
KA500, *KD500*, *KE500*, *KF500*	10	11	12	13	14	15	16
KA550, *KD550* , *KE550*, *KF550*	10	11	12	13	14	15	16
KA620, *KD620*, *KE620*, *KF620*, *KA620N*, *KD620N*, *KE620N* , *KF620N*	9	11	12	12	13	14	15
KA690, *KD690*, *KE690*, *KF690*, *KA690N*, *KD690N*, *KE690N* , *KF690N*	9	10	11	11	12	13	14

Table 3.30 Impact Test for Steels Specified in IGC Code

Grade	Thickness	Impact test		
		Testing temperatura (˚C)	Minimum mean absorbed energy (*J*)	
			L	*T*
*KA*420, *KD*420, *KA460*, *KD460*, *KA500*, *KD500*, *KA550*, *KD550*, *KA620*, *KD620*, *KA620N*, *KD620N*, *KA690*, *KD690*, *KA690N KD690N*	$t \leq 20$	0	41	27
	$20 < t \leq 40$	-20		
	$40 < t \leq 50$	-30		
	$50 < t$	as deemed appropriate by the Society		

3.9 Stainless Clad Steel Plates

3.9.1 Application

1. The requirements in Section 3.9 are to apply to the stainless clad steels not exceeding 50 *mm* in thickness intended for tanks of ships carrying dangerous chemicals in bulk, tank circumference hull construction units, and corrosion-resisting tanks (hereinafter referred to as "steel plates" in 3.9).

2. The requirements other than those specified in Section 3.9are to apply to 3.1.

3. Any requirements regarding the steel plates over 50 *mm* in thickness are left to the discretion of the Society.

4. Steel plates having characteristics differing from those specified in 3.9 are to comply with the requirements in 1.1.1-2.

3.9.2 Process of Manufacture

1. Manufacture of steel plates is to comply with the processes shown in **(1)** to **(5)** below:

(1) Rolling

(2) Cast rolling

(3) Explosive pressing

(4) Explosive rolling

(5) Overlay rolling

2. Application of any other process of manufacture than those specified in **-1** is left to the discretion of the Society.

3.9.3 Structural Metals

1. Base and cladding metals for steel plates are to be steel plates of rolled steels for hull specified in 3.1 and steel plates of rolled stainless steels, except *KSUS*329*J*3*L*, specified in 3.5 respectively. However, the standard thickness of cladding metals is not less than 1.5 *mm*.

2. The symbol of the plate is to be of combination of that of the base plates and the cladding metals.

3.9.4 Heat Treatment

The steel plates are to comply with the requirements for heat treatment of the base metal.

3.9.5 Mechanical Properties

The steel plates are to conform to the requirements given in Table 3.31 as to mechanical properties.

Table 3.31 Mechanical Properties

Kind of base metal	Grade of base metal	Tensile test(1)			Sheering stregth test (3)	Impact test
		Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)	Sheering strength (N/mm^2)	
Mind steel	*KA, KB KD,KE*	235 min.	$\sigma_B$min.(2)	To be complied with the requirement for base metal	200 min.	To be complied with the requirement for base metal
High tensile steel	*KA*32, *KA*36 *KD*32, *KD*36 *KE*32, *KE*36 *KF*32, *KF*36	$\sigma_y$min.(2)				

Notes:

1 The tensile test specimen is to be U1 test specimen.

2 σ_y and σ_B are to be obtained from the following formulae:

$$\sigma_y = \frac{t_1\,\sigma_{y1}+t_2\,\sigma_{y2}}{t_1+t_2}\ (N/mm^2)$$

$$\sigma_B = \frac{t_1\,\sigma_{B1}+t_2\,\sigma_{B2}}{t_1+t_2}\ (N/mm^2)$$

t_1: Thickness of base metal (*mm*)

t_2: Thickness of cladding metal (*mm*)

σ_{y1}: Specified minimum yield point or proof stress of base metal (N/mm^2)

σ_{y2}: Specified minimum yield point or proof stress of cladding metal (N/mm^2)

σ_y: Yield point or proof stress of steel plate (N/mm^2)

σ_{B1}: Specified minimum tensile strength of base metal (N/mm^2)

σ_{B2}: Specified minimum tensile strength of cladding metal (N/mm^2)

σ_B: Tensile strength of steel plate (N/mm^2)

3 Shear strength test is applied for the case that the thickness of cladding metals is not less than 1.5 *mm*. Any requirement for the procedure of the test is left to the discretion of the Society.

3.9.6 Other Properties

Where deemed necessary by the Society according to the use of steel plates, tests on corrosion resistance may be required.

3.9.7 Selection of Test Samples

1. One test sample is to be taken from each steel plate, being from the same manufacturing process, which belongs to the plate as rolled from a slab or ingot of a certain base metal.

2. The requirements specified in **3.1.6-4** are to be applied to the selection of the test samples.

3.9.8 Selection of Test Specimens

1. Tensile test specimens are to be taken according to the requirements specified in **3.1.7-2.**

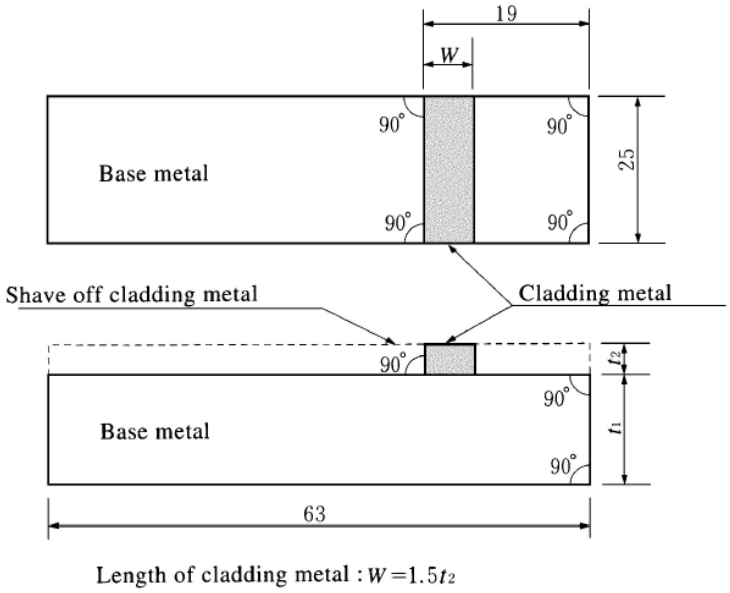
2. Impact test specimens are to be taken according to the requirements specified in **3.1.7-3**. In this case, the thickness of the test specimens is to agree with that of the base metal from which the cladding metal has been removed.

3. Shearing strength test specimens are to be taken according to the requirements specified in the following **(1)** to **(2)**:

(1) One test specimen is to be taken from one test sample.

(2) The size and dimensions of the test specimens are to be determined according to **Fig. 3.3.**

Fig. 3.3 Size and Dimensions of Shearing Test Specimens (unit: *mm*)



3.9.9 Surface Inspection and Verification of Dimensions

1. Surface inspection and verification of dimensions are the responsibility of the manufacturer.

2. The minus tolerance in the nominal thickness of plates is left to the discretion of the Society.

3.9.10 Quality and Repair of Defects

1. Each steel plate is to be subjected to ultrasonic testing. Any requirement for the test procedure is left to the discretion of the Society.

2. Any defects on the surface or joints of material found by the ultrasonic testing, etc. may be repaired by welding, subject to the special approval by the Society.

3.9.11 Marking

1. The test certificates are to comply with the requirements given in 1.5.2 and are to contain the particulars as to the process of manufacture of steel plates and the thickness of the cladding metal.

2. Steel plates which have satisfactorily complied with the required tests are to be suffixed with the following marks relating to the process of manufacture of the steel plates, in addition to the marks showing the kinds of the base and cladding metals.

(Example: *KA* + *KSUS*316*L*-*R*).

Rolling: "- *R*"

Cast rolling: "-*ER*"

Explosive pressing: "-*B*"

Explosive rolling: "-*BR*"

Overlay rolling: "-*WR*"

3.10 Additional Requirements for Rolled Steel Plates for Hull with Thickness above 50 *mm* up to 100 *mm*

3.10.1 Application

1. This provision is to apply to hull structural rolled steel plates (including steel flats not less than 600 *mm* in width, hereinafter referred to as steel plates in 3.10) with thickness above 50 *mm* up to 100 *mm*.

2. The requirements other than those specified in 3.10 are to apply to 3.1.

3.10.2 Kinds

The steel plates are classified into the grades as given in Table 3.32.

3.10.3 Deoxidation Practice and Chemical Composition

1. The deoxidation practice and chemical composition of each grade are to comply with the requirements given in Table 3.32. The requirements on the chemical composition of steel plates may be modified subject to the approval by the Society.

2. The carbon equivalent of steels may be required to be submitted when specially required by the Society.

Table 3.32 Kinds, Deoxidation Practice and Chemical Composition Steel Plates (%)

Kind	Grade	Deoxidation Practice	Chemical Composition (%)															Carbon equivalent(%)
			C	*Si*	*Mn*	*P*	*S*[9]	*Cu*	*Cr*	*Ni*	*Mo*	*Al*[3]	*Nb*	*V*	*Ti*	*N*		
Mild Steels	*KA*	Killed	0.21 max. (2)	0.50 max.	2.5XC min. (2)	0.035 max.	0.035 max.	-	-	-	-		-	-	-	-		
	KB			0.35 max.	0.60 min. (2)							-						-
	KD	Killed and fine grain treated																
	KE		0.18 max. (2)		0.70 min (2)							0.015 min. (6)						
High Tensile Steels	*KA*32	Killed and fine grain treated	0.18 max.	0.50 max	0.90 ~ 1.60	0.035 max.	0.035 max.	0.35 max.	0.20 max.	0.40 max.	0.08 max.	0.015 min. (4)	0.02 ~ 0.05 (4) (5)	0.05 ~ 0.10 (4) (5)	0.02 max. (5)	-		(8)
	*KD*32																	
	*KE*32																	
	*KA*36																	
	*KD*36																	
	*KE*36																	
	*KA*40																	
	*KD*40																	
	*KE*40																	
	*KF*32		0.16 max.			0.025 max	0.025 max			0.80 max						0.009 max (7)		
	*KF*36																	
	*KF*40																	

Notes:

1 Where additions of any other element have been made as part of the steel making practice, the content is to be indicated on the test certificate.

2 The value of $C + Mn/6$ is not to exceed 0.40%.

3 Aluminium content is to be represented by the acid soluble aluminium content, but may be determined by the total aluminium content. In such case, the total aluminium content is not to be less than 0.020%.

4 The steel is to contain aluminium, niobium, vanadium or other suitable grain refining elements, either singly or in any combination. When used singly, the steel is to contain the specified minimum content of the grain refining element.

When used in combination, the specified minimum content of each grain refining element is not applicable.

5 The total niobium, vanadium and titanium content is not to exceed 0.12%.

6 Upon the approval by the Society, grain refining elements other than aluminium may be used.

7 The maximum content of nitrogen may be increased to 0.012% if aluminium is contained.

8 Carbon equivalent is to be recorded on test certificate. When any grade of higher strength steel is supplied in the *TMCP* condition, the carbon equivalent is to comply with the requirements of **Table 3.33**.

9 For steels complying with the requirements specified in **3.11** the maximum content of sulphur is to be 0.008% determined by the ladle analysis.

Table 3.33 Carbon Equivalent for Steels Produced by TMCP

Grade	Carbon equivalent(%)(1)
KA32, KD32, KE32, KF32	0.38max
KA36, KD36, KE36, KF36	0.40max
KA40,KD40, KE40, KF40	0.42max.

Note:

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

3.10.4 Heat Treatment

The heat treatment of each grade is to comply with the requirements given in **Table 3.34**.

3.10.5 Mechanical Properties

The mechanical properties of steel plates are to comply with requirements given in **Table 3.34**.

Table 3.34 Heat Treatment and Mechanical Properties

tGrade	Heat treatment(1)	Tensile test			Impact test(4)				
		Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation $L = 5.65\sqrt{A}$ (%)	Testing temperature (˚C)	Minimum mean absorbed energy (J)(5)			
						Thickness t (mm)			
						$50 < t \leq 70$		$70 < t \leq 100$	
						L	T	L	T
KA	*TMCP, N*(2)	235 min	400~520	22 min	+20(6)	34(6)	24(6)	41(6)	27(6)
KB					0	34	24	41	27
KD	*TMCP, N*(3)				-20				
KE	*TMCP, N*				-40				
*KA*32	*TMCP, N*	315min	400~590	22 min	0	38	26	46	31
*KD*32					-20				
*KE*32					-40				
*KF*32	*TMCO, N, QT*				-60				
*KA*36	*TMCP, N*	355 min	490~620	21 min	0	41	27	50	34
*KD*36					-20				
*KE*36					-40				
*KF*36	*TMCP, N, QT*				-60				
*KA*40	*TMCP, N, QT*	390 min	510~650	20 min	0	46	31	55	37
*KD*40					-20				
*KE*40					-40				
*KF*40					-60				

Notes:

1 *See* **Note (3)** of **Table 3.3.**

2 *AR* or *CR* (hereinafter referred to as "*ARS*" or "*CRS*" in **3.10**) may be accepted, subject to the approval by the Society.

3 *CRS* may be accepted.

4 *L* (or *T*) denotes that the longitudinal axis of the test specimen is arranged parallel (or transverse) to the final direction of rolling.

5 When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified minimum mean absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified minimum mean absorbed energy, the test is considered to be failed.

6 It may be applied in case where the heat treatment is *ARS* or *CRS*. (*See*, **Note (2)**)

3.10.6 Selection of Test Samples

The test samples are to be taken according to the following **(1)** and **(2)**.

(1) In the case of ingot casting the test samples are to be taken from a position representing the top of the ingot.

(2) The lot for the impact test is given in **Table 3.35**.

Table 3.35 Size of Lot for Impact Test

Grade	Heat treatment and size of lot
KA	$TMCP < ->, N < ->, CRS < 50 >, ARS < 50 >$
KB	$TMCP < 50 >, N < 50 >, CRS < 25 >, ARS < 25 >$
KD	$TMCP < 50 >, N < 50 >, CRS < 25 >$
KE	$TMCP < P >, N < P >$
*KA*32, *KA*36	$TMCP < 50 >, N < 50 >$
*KD*32, *KD*36	
*KE*32, *KE*36	$TMCP < P >, N < P >$
*KA*40, *KD*40	$TMCP < 50 >, N < 50 >, QT < PH >$
*KE*40, *KF*32,*K F*36, *KF*40	$TMCP < P >, N < P >, QT < PH >$

Note:

In the Table, "mark" put at the end of each "symbol" for heat treatment (*See* **Notes (1)** and **(2)** of **Table 3.34**) stand for the volume of each lot. For examples, <50> and <25> each indicate that steel plates not greater in mass than 50 and 25 *tonnes* (belonging to the same manufacturing process in the same charge) are to be taken as one lot; <*P*> indicates that steel plate rolled directly from one slab or steel ingot (belonging to the same heat treatment condition) is to be taken as one lot; <*PH*> indicates that steel plate rolled directly from one slab

or steel ingot and heat treated simultaneously in the same furnace including continuous furnace is to be taken as one lot; and <->indicates that no impact test is required.

3.11 Additional Requirements for Through Thickness Properties

3.11.1 Application

1. The provisions given in **3.11** are to apply to the steels which are required improved through thickness properties relating to the structural design.

2. The requirements are to apply to hull structural rolled steels and high strength quenched and tempered rolled steels for plates and wide flats with thickness of 15 *mm* and over.

3. The requirements are applicable to the other steels than the material specified in **-2** above, where deemed appropriate by the Society.

3.11.2 Through Thickness Properties

1. The through thickness properties of steels are to conform to the requirements in **Table 3.36** as the result of tensile tests whose specimens are taken in the through thickness direction of the product.

Table 3.36 Through Thickness Properties

Kind of Steels	Suffix	Tensile test in the through thickness direction	
		Reduction of area (%)	
		Average value of three specimens	One individual value(1)
Rolled Steels for Hull High Strength Quenched and Tempered Rolled Steels for Structures	*Z*25	25min	15min
	*Z*35	35min	25min

Note:

1 If two or more individual results are less than the specified average value, the test is considered to be failed.

3.11.3 Selection of Test Samples

1. For steel, of same thickness, belonging to the same charge and same heat treatment condition, one test sample is to be taken from each lot specified in **Table 3.37**.

2. The test samples are to be taken from one end (top of ingot when applicable) of the portion corresponding to the middle of the plates or flat bars as shown in **Fig. 3.4.**

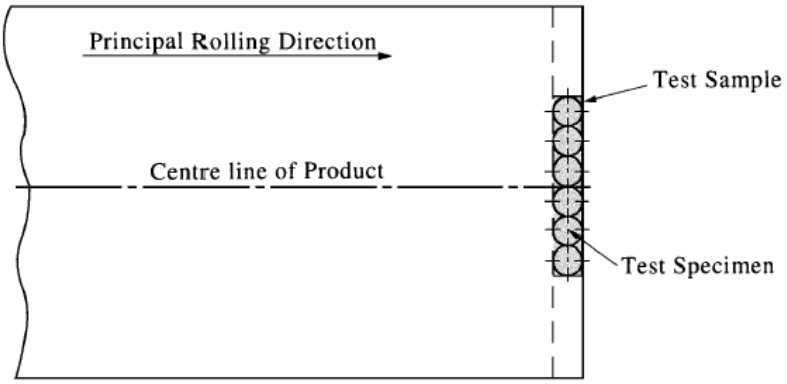
Table 3.37 Lot for Tensile Test in the Through Thickness Direction

Product	Content of S	
	$S \leq 0.005\%$	$0.005\% < S$
Plates		$< P >$
Wide flats of nominal thickness $\leq 25mm$	$< 50 >$	$< 10 >$
Wide flats of nominal thickness $> 25mm$		$< 20 >$

Note:

In the Table, <50>, <20> and <10> each indicate that steels not greater in mass than 50, 20 and 10 *tonnes* are to be taken as one lot; <*P*> indicates that steel rolled directly from one slab or steel ingot is to be taken as one lot.

Fig. 3.4 Selection of Test Samples



3.11.4 Selection of Test Specimens

1. Three tensile test specimens are to be taken from one test sample in the through thickness direction.

2. The test specimens are to be taken according to the requirements for dimensions provided in **Table 3.38**.

3. Where the product thickness does not allow to prepare specimens of sufficient length suitable for the gripping jaws of the testing machine, the ends of the specimens may be built up by suitable welding methods. The welding is not to impair the portion of the specimen within the parallel length.

Table 3.38 Dimensions of Specimen

Product thickness t *(mm)*	Diameter of test specimen $d(mm)$	Parallel length $L(mm)$
$15 \leq t \leq 25$	$d = 6$	$9 \leq L$
$25 < t$	$d = 10$	$15 \leq L$

3.11.5 Non-Destructive Testing

1. Each steel, complying with the requirements specified in **3.11**, which rolled directly from one slab, ingot, etc. (belonging to the same heat treatment condition) is to be subjected to ultrasonic testing. Any requirement for the test procedure and judgment are left to the discretion of the Society.

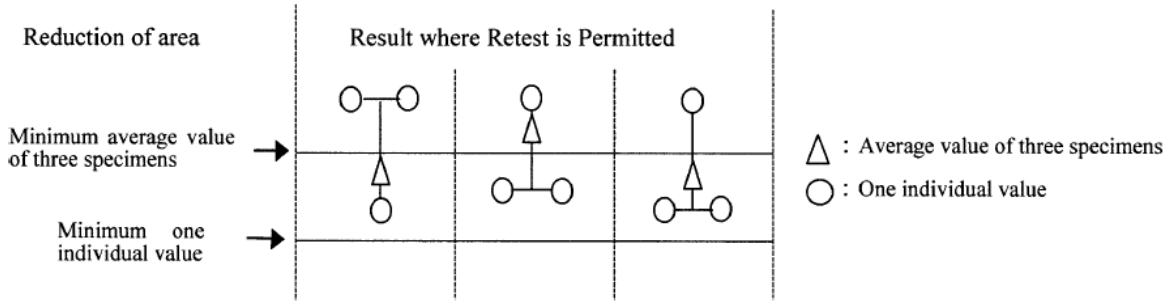
3.11.6 Additional Tests before Rejection

1. Where the tensile test in the through thickness direction fails to meet the requirements and where a retest is permitted according to **Fig.3.5**, three more tests are to be carried out on the remaining test pieces.

2. As the results of the retest according to the above **-1**, the average of the results of all six tests is to be greater than the required minimum average with no greater than two results below the minimum average.

3. In the case of failure after retest, either the batch represented by the piece is rejected or each piece within the batch is required to be tested.

Fig. 3.5 Result where Retest is Permitted



3.11.7 Marking

For the products complying with the requirements specified in **3.11**, *Z*25 or *Z*35 given in **Table 3.36** is to be suffixed to the markings. (Example: *KD*36-Z25 for *KD*36.)

3.12 Additional Requirements for Brittle Crack Arrest Properties

3.12.1 Application

1. The provisions given in **3.12** are to apply to the steels which are specially considered so as to have brittle crack arrest properties relating to the structural design.

2. The requirements are to apply to hull structural rolled steels for plates (*KE*, *KE*32, *KE*36, *KE*40, *KF*32, *KF*36 and *KF*40).

3. The requirements are applicable to steels other than those specified in **-2** above, where deemed appropriate by the Society.

3.12.2 Brittle Crack Arrest Properties etc.

1. The brittle crack arrest properties of steel plates are to conform to the requirements in **Table 3.39** as the result of temperature gradient *ESSO* tests or double tension tests. Any requirements for the test procedure are left to the discretion of the Society.

2. A brittle fracture test deemed appropriate by the Society may be substituted for temperature gradient *ESSO* tests or double tension tests specified in **-1**.

Table 3.39 Brittle Crack Arrest Properties

Kinds of Steels		Kinds of properties	Temperature gradient ESSO test and double tension test	
			Evaluation Temperature (˚C)	Brittle Crack Arrest Toughness Value Kca (N/mm1.5)
Rolled Steels for Hull	KE, KE32, KF32, KE36, KF36, KE40, KF40	A400	-10	min. 4000
		A500	-10	min. 5000
		A600	-10	min. 6000

3.12.3 Selection of Test Samples

1. For the samples, steel plates (of same thickness, belonging to the same charge and same heat treatment condition), which are not greater in weight than 50 *ton*, are to be treated as one lot, and one test sample is to be taken from each lot.

2. The test samples are to be taken from one end (top of ingot when applicable) of the portion corresponding to the middle of the plate width.

3.12.4 Selection of Test Specimens

1. Two test specimens are to be taken from one test sample.

2. The test specimens are to be taken with their longitudinal axis parallel to the final direction of rolling.

3. Thickness of the test specimens is to be same thickness of the steel plates.

4. The dimensions and types of the assembly, except the requirement specified in **-3**, are left to the discretion of the Society.

3.12.5 Additional Tests before Rejection

1. Where the result of temperature gradient *ESSO* tests or double tension tests fails to meet the requirements, those tests may be carried out additionally on two more test specimens. In this case, the judgment of acceptance is to be made on the Brittle Crack Arrest Toughness Value of all four test specimens.

3.12.6 Marking

For the products complying with the requirements specified in **3.12**, *A*400 or *A*600 given in **Table 3.39** is to be suffixed to the markings. (Example: *KE*40-*A*400 for *KE*40)

Chapter 4 STEEL PIPES

4.1 Steel Tubes for Boilers and Heat Exchangers

4.1.1 Application

1. The requirements mainly apply to steel tubes intended for heat transfer at inside or outside of the tubes; for example, smoke tubes, water tubes, stay tubes, super-heater tubes of boilers, other tubes for high temperature heat exchangers, etc. (hereinafter referred to as steel tubes in 4.1).

2. Steel tubes having characteristics differing from those specified in 4.1 are to comply with the requirements in 1.1.1-2.

4.1.2 Kinds

The steel tubes are classified into 7 grades as specified in Table 4.1.

4.1.3 Heat Treatment

The steel tubes are to be heat treated in accordance with the requirements in Table 4.2.

4.1.4 Chemical Composition

The steel tubes are to have the chemical composition given in Table 4.3.

Table 4.1 Grades of Tubes

Grade	Symbol	Description
Grade 2	*KSTB*33	Low carbon seamless steel tubes and electric-resistance welded steel tubes
Grade 3	*KSTB*35	Low carbon killed seamless steel tubes and electric-resistance welded steel tubes
Grade 4	*KSTB*42	Medium carbon killed seamless steel tubes and electric-resistance welded steel tubes
Grade 12	*KSTB*12	$\frac{1}{2}Mo$ alloy seamless steel tubes and electric-resistance welded steel tubes
Grade 22	*KSTB*22	$1Cr-\frac{1}{2}Mo$ alloy seamless steel tubes and electric-resistance welded steel tubes
Grade 23	*KSTB*23	$1\frac{1}{4}Cr-\frac{1}{2}Mo-\frac{3}{4}Si$ alloy seamless steel tubes
Grade 24	*KSTB*24	$2\frac{1}{4}Cr-1Mo$ alloy seamless steel tubes and electric-resistance welded steel tubes

Note:

The symbols indicating the method of manufacture are to be fitted at the end of the above symbols, as follows:

Hot finished seamless steel tube: *-S-H*

Cold finished seamless steel tube: *-S-C*

Electric-resistance welded steel tube of other than hot and cold working: *-E-G*

Electric-resistance welded steel tube of hot working: *-E-H*

Electric-resistance welded steel tube of cold working: *-E-C*

Table 4.2 Heat Treatment for Tube

Grade	Seamless steel tube		Electric-resistance welded steel tube		
	Hot finished	Cold finished	As welded	Hot finished	Cold finished
Grade 2	As manufactured (1)	Low temperature annealing, normalizing or full annealing	Normalizing	As manufactured(1)	Normalizing(2)
Grade 3					
Grade 4			Normalizing	Low temperature annealing	Normalizing(2)
Grade 12	Low temperature annealing, isothermal annealing, full annealing, normalizing or normalizing followed by tempering		Isothermal annealing, full annealing, normalizing or normalizing followed by tempering.		
Grade 22	Low temperature annealing, isothermal annealing, full annealing or normalizing followed by tempering		Isothermal annealing, full annealing or normalizing followed by tempering		
Grade 23	Isothermal annealing, full annealing or normalizing followed by tempering at 650˚C and over		-		
Grade 24			Isothermal annealing, full annealing or normalizing followed by tempering at 650˚C and over		

Notes:

1 Low temperature annealing or normalizing may be applied if necessary.

2 The cold finished electric resistance welded steel tubes which are normalized prior to cold finishing may be finished by annealing.

Table 4.3 Chemical Composition

Grade	Chemical composition (%)						
	C	*Si*	*Mn*	*P*	*S*	*Cr*	*Mo*
Grade 2	0.18 max.	0.35 max.	0.25~ 0.60	0.035 max.	0.035 max.	-	-
Grade 3	0.18 max.	0.10~ 0.35	0.30~ 0.60	0.035 max.	0.035 max.	-	-
Grade 4	0.32 max.	0.10~ 0.35	0.30~ 0.80	0.035 max.	0.035 max.	-	-
Grade 12	0.10 to 0.20	0.10~ 0.50	0.30~ 0.80	0.035 max.	0.035 max.	-	0.45~ 0.65
Grade 22	0.15 max.	0.50 max.	0.30~ 0.60	0.030 max.	0.035 max.	0.80~ 1.25	0.45~ 0.65
Grade 23	0.15 max.	0.50~ 1.00	0.30~ 0.60	0.030 max.	0.030 max.	1.00~ 1.50	0.45~ 0.65
Grade 24	0.15 max.	0.50 max.	0.30~ 0.60	0.030 max.	0.030 max.	1.90~ 2.60	0.87~ 1.13

Note:

In case where approved by the Society, Grades 3 and 4 may be killed steel with below 0.10% *Si*.

4.1.5 Mechanical Properties

The steel tubes are to conform to be following requirements as to mechanical properties:

(1) Tensile test

The steel tubes are to conform to the requirements in **Table 4.4**.

(2) Flattening test

A tubular section which is taken from the end of the tube is to stand being flattened cold between parallel plates, without cracking or showing flaw, until the distance between the plates becomes less than the value of H calculated by the following formula. In this case, Length L is to be not less than 50 *mm*, however, not more than 100 *mm*. For tubes, however, of 15% of outside diameter and over in thickness, C-type test specimen may be used, having a part of its circumference discarded as shown in **Fig. 4.2**.

$$H = \frac{(1+\mathrm{e})t}{\mathrm{e} + \frac{t}{D}}$$

Where:

H: Distance between flattening plate (*mm*)

t: Thickness of tube (*mm*)

D: Outside diameter of tube (*mm*)

e: Constant given in **Table 4.5** which varies according to the grade of tubes

For electric-resistance welded tubes, however, the welded line is to be placed at right angle to the direction of the applied force as shown in **Fig. 4.1**. Where C-type test specimen is used, it is to be placed as in **Fig. 4.2**.

(3) Flanging test

A section of tube which is taken from its end is to be turned over cold so as to have a flange, the outside diameter of which is not less than specified in **Table 4.6** at right angle to the axis without cracking or showing flaw. In this case, the flanging test specimen is to be of length L such that after testing the remaining cylindrical portion is not less than 0.5 D. But, this test is to be made only for Grade 2 tube having wall thickness not more than 1/10 of its outside diameter and not more than 5 *mm*.

(4) Flaring test

A section of tube which is taken from its end is to stand being flared cold with a tool having an included angle of 60 *degrees*, until the tube at the mouth of the flare is expanded without cracking or showing flaw to the diameter shown in **Table 4.7**. In this case, the length of test specimen is to be 1.5 D, however, not less than 50 *mm*. For Grade 2 tubes which require the flanging test, this test need not be carried out.

(5) *Crushing Test*

For Grade 2 tubes, where required by the Surveyor, a crushing test is to be made on a section of tube of 65 *mm* in length which is to stand crushing longitudinally without cracking or splitting to the height specified in **Table 4.8**.

(6) Reverse flattening test

A section of tube of 100 *mm* in length which is taken from the tube is to be slotted longitudinally on the opposite side of the welded line, opened and flattened without cracking or showing flaw on the inside of the welded line.

There is also to be no misalignment, lack of penetration, and overlap. But, this test is applied to electric-resistance welded tubes only.

(7) Hydraulic test

(a) Tubes are to be hydraulically tested to a satisfactory result by 2 times and over the maximum working pressure at the mill. But the minimum test pressure is to be 7.0 *MPa*.

(b) The test pressure prescribed in **(a)** need not exceed the pressure calculated by the following formula:

$$P = 2St/D$$

where:

P: Hydraulic test pressure (*MPa*)

t: Thickness of tube (*mm*)

D: Outside diameter of tube (*mm*)

S: 60% of the prescribed minimum yield point or proof stress (N/mm^2)

(c) Where each tube is hydraulically tested as a regular procedure during the process of manufacturing at the mill, which makes a number of tubes continually, and the results are forwarded to the Surveyor, the test in the presence of the Surveyor may be dispensed with.

(d) A non-destructive test deemed appropriate by the Society may be substituted for the hydraulic test specified **(a)**.

Table 4.4 Tensile Test

Grade	Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) ($L = 5.65\sqrt{A}$)
Grade 2	175min.	325min.	26(22)min.
Grade 3	175min.	340min.	26(22)min.
Grade 4	255min.	410min.	21(17)min.
Grade 12	205min.	380min.	21(17)min.
Grade 22, 23 & 24	205min.	410min.	21(17)min.

Notes:

1 The values of elongation in parentheses are applicable to the test specimens taken transversely.
In this case, the sampling material is to be heated 600°C to 650°C after flattened and annealed in order to make it free from strain.

2 In case where a test specimen of non-tubular section is taken from an electric-resistance welded tube, the test specimen is to be taken from the part that does not include the welded line.

Table 4.5 Value of *e*

Grades 2&3	0.09
Others	0.08

Fig. 4.1 Flattening Test

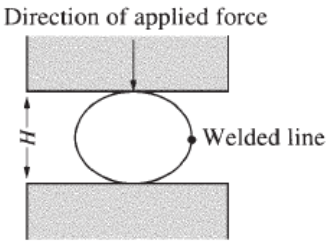


Fig. 4.2 Flattening Test for C-type Test Specimen

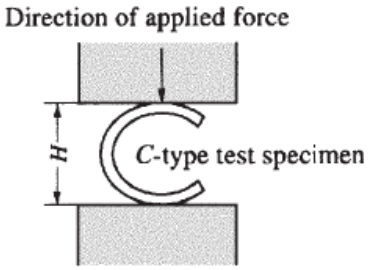


Table 4.6 Outside Diameter or Flange after Flanging

Outside diameter of tube D (*mm*)	Outside diameter of flange (*mm*)
$D < 63$	1.3D
$D \geq 63$	D+20

Table 4.7 Outside Diameter or Tube End after Flaring

Grade	Outside diameter of tube end (*mm*)
Grades 2, 3&4	1.2D
Grades 12, 22, 23&24	1.14D

Table 4.8 Height of Section after Crushing

Thickness of tube t (mm)	Height of section after crushing
$t \leq 3.4$	19mm or until outside folds are in contact
$t > 3.4$	$32mm$

4.1.6 Selection of Test Specimen

The test specimens are to be taken in accordance with the requirements in **(1)** and **(2)**, from each grade and each size which has been heat treated at the same time in the same heating furnace for heat-treated tubes and from each grade and each size for non-heat-treated tubes respectively.

(1) Seamless steel tubes

(a) Grade 2

One sampling tube is to be selected from each lot of 100 tubes or fraction thereof, and one tension, one flattening and one flanging or flaring test specimens are to be taken from each of the sampling tubes.

(b) Other than Grade 2

One sampling tube is to be selected from each lot of 50 tubes or fraction thereof and each one specimen for tensile test, flattening test and flaring test is to be taken from the sampling tubes.

(2) Electric-resistance welded steel tubes

For electric-resistance welded steel tubes, in addition to the requirements in **(1)**, one sampling tube is to be selected from each lot of 100 tubes or fraction thereof, and one reverse flattening test specimen is to be taken from each of the sampling tubes.

(3) Tensile test specimen is to comply with the requirements specified in **Table 2.1**.

4.1.7 Tolerances for Dimensions of Tubes

The tolerances for the outside diameter and thickness are to be in accordance with the requirements in **Table 4.9**.

Table 4.9(a) Tolerance for Outside Diameter of Tubes (*mm*)

Kind	Outside diameter of tube									
	$D < 100$		$100 \leq D < 160$		$160 \leq D < 200$		$200 \leq D$			
Hot finished seamless steel tube	+0.4 -0.8		+0.4 -1.2		+0.4 -1.8		+0.4 -2.4			
Kind	Outside diameter of tube									
	$D < 25$	$25 \leq D < 40$	$40 \leq D < 50$	$50 \leq D < 60$	$60 \leq D < 80$	$80 \leq D < 100$	$100 \leq D < 120$	$120 \leq D160$	$160 \leq D < 200$	$200 \leq D$
Cold finished seamless steel tuve and electric-resisitance welded steel tube of cold working	±0.10	±0.15	±0.20	±0.25	±0.30	±0.40	+0.40 -0.60	+0.40 -0.80	+0.40 -1.20	+0.40 -1.60
Electric-resistance welded steel tuve other tan of cold working	±0.15	±0.20	±0.25	±0.30	±0.40	+0.40 -0.60	+0.40 -0.80	+0.40 -1.00	+0.40 -1.20	+0.40 -1.60

Table 4.9(b) Tolerances for Thickness of Tube (% except where specially noted)

Kind	Outside diameter D (mm)	Thickness *t (mm)*				
		$t < 2$	$2 \leq t < 2.4$	$2.4 \leq t < 3.8$	$3.8 \leq t < 4.6$	$4.6 \leq t$
Hot finished seamless steel tube	$D < 100$	-	+40	+35 0	+33 0	+28 0
	$D \geq 100$	-	-	+35 0	+33 0	+28 0
Cold finished seamless steel tube and electric-resistance welded steel tube of cold working	$D < 40$	+0.4*mm* 0	+20 0			
	$D \geq 40$	+0.22 0				
Electric-resistance welded steel tube other than of cold working	$D < 40$	+0.3 *mm* *0*	+18 0			
	$D \geq 40$	+0.18 0				

Note:

For hot finished seamless steel tubes, the tolerance for deviation in wall thickness is to be 22.8% and under of the thickness of the tube. But, for tubes less than 5.6 *mm* in thickness, this note in not applied.

4.1.8 Quality

The steel tubes are to be of uniform quality and free from harmful defects. For electric-resistance welded tubes, deposit metal projected on outside of tubes is to be removed and finished smooth and that projected on inside of tubes is to be removed to have a height not more than 0.25 *mm*.

4.1.9 Marking

The name or brand of the manufacturer, grade of tubes, symbol of the method of the manufacture and size are to be legibly stamped or stenciled before shipment on each length tube in case of 30 *mm* and above in outside diameter and on each bundle or container of tubes in case of less than 30 *mm* in outside diameter. The Society s brand indicating compliance with the requirements is to be stamped in the vicinity of the foregoing marks.

4.2 Steel Pipes for Pressure Piping

4.2.1 Application

1. The requirements are mainly to apply to steel pipes intended for use in pipings classified as Group 1 and Group 2 specified in Part 7 (hereinafter referred to as steel pipes in 4.2).

2. Carbon steel pipes for ordinary piping (steel gas pipes) specified in **12.1.5-1,** Part 7 are to be in accordance with the followings, regardless of the requirements in **1.2**, **1.4** and **4.2.2** to **4.2.9**.

(1) They are to conform to the requirements in *recognized national or international standards* (Carbon Steel Pipes for Ordinary Piping).

(2) The manufacturing approval tests by the Society is not required.

3. Steel pipes having characteristics differing from those specified in 4.2 are to comply with the requirements in 1.1.1-2.

4.2.2 Kinds

The steel pipes are classified into 12 grades as specified in Table 4.10.

4.2.3 Heat Treatment

The steel pipes are to be heat treated in accordance with the requirements in Table 4.11.

4.2.4 Chemical Composition

The steel pipes are to have the chemical composition given in Table 4.12.

4.2.5 Mechanical Properties

The steel pipes are to conform to the following requirements as to mechanical properties:

(1) Tensile test

The steel pipes are to be subjected to tensile test and to conform to the requirements in Table 4.13.

(2) Bend test

A test specimen of tubular section which is taken from the end of the pipe and has sufficient length is to stand being bent cold, up to the specified value in **Table 4.14**, without cracking or showing flaw on the wall. But, for Grade 4, this test need not be carried out.

(3) Flattening test

A tubular section of pipe which is taken from the end of the pipe, is to stand being flattened cold between parallel plates, without cracking or showing flaw, until the distance between the plates becomes less than the value of *H* calculated by the following formula. In this case, the length of test specimen is to comply with the requirements specified in **4.1.5(2)**. For pipes, however, of 15% of outside diameter and above in thickness, C-type test specimen may be used, having a part of its circumference discarded as shown in **Fig. 4.3**.

(a) Pipes other than Grade 1 of electric-resistance welded pipe

$$H = \frac{(1 + e)t}{e + t/D}$$

where:

H: Distance between flattening plates (*mm*)

t: Thickness of pipe (*mm*)

D: Outside diameter of pipe (*mm*)

e: Constant given in **Table 4.15**.

(b) Electric-resistance welded pipes Grade 1

$H = 2D / 3$ for welded line,

$H = D / 3$ for elsewhere

In case of electric-resistance welded pipes, the welded line is to be placed at right angle to the direction of the applied force, as in **Fig. 4.1**. Where C-type test specimen is used, it is to be placed as in **Fig. 4.2**.

(4) Hydraulic test

(a) Pipes are to be hydraulically tested with the pressure specified in **Table 4.16**.

(b) In case where the test pressure higher than prescribed in **(a)** is specified by the purchaser, the test is to be carried out with the specified pressure.

In this case, test pressure need not exceed the pressure calculated by the following formula:

$P = 2St / D$

where:

P: Hydraulic test pressure (*MPa*)

D: Outside diameter of pipe (*mm*)

t: Thickness of pipe (*mm*)

S: 60% of the prescribed minimum yield point or proof stress (N/mm^2)

(c) When each pipe is hydraulically tested as a regular procedure during the process of manufacturing at the mill which marks a number of pipes continually, and the results are forwarded to the Surveyor, the test in the presence of the Surveyor may be dispensed with.

(d) A non-destructive test deemed appropriate by the Society may be substituted for the hydraulic test specified in **(a)**.

Table 4.10 Grades of pipes

Grade		Symbol	Description
Grade 1	No. 2	*KSTPG*38	Low carbon seamless steel and electric-resistance welded steel pipe
	No. 3	*KSTPG*42	Medium carbon seamless steel and electric-resistance welded steel pipe
Grade 2	No. 2	*KSTS*38	Low carbon killed seamless steel pipe
	No. 3	*KSTS*42	Medium carbon killed seamless steel pipe
	No. 4	*KSTS*49	
Grade 3	No. 2	*KSTPT*38	Low carbon coarse grain killed seamless pipe and electric-resistance welded steel pipe
	No. 3	*KSTPT*42	Medium carbon coarse grain killed seamless steel pipe and electric-resistance welded steel pipe
	No. 4	*KSTPT*49	Medium carbon coarse grain killed seamless steel pipe
Grade 4	No. 12	*KSTPA*12	$\frac{1}{2}Mo$ alloy seamless steel pipe
	No. 22	*KSTPA*22	$1Cr-\frac{1}{2}Mo$ alloy seamless steel pipe
	No. 23	*KSTPA*23	$1\frac{1}{4}Cr-\frac{1}{2}Mo-\frac{3}{4}Si$ alloy seamless steel pipe
	No. 24	*KSTPA*24	$2\frac{1}{4}Cr-1Mo$ alloy seamless steel pipe

Notes:

The symbols indicating the method of manufacture are to be fitted at the end of the above symbols, as follows:

Hot finished seamless steel pipe:	*-S-H*
Cold finished seamless steel pipe:	*-S-C*
Electric-resistance welded steel pipe of other than hot & cold working:	*-E-G*
Electric-resistance welded steel pipe of hot working:	*-E-H*
Electric-resistance welded steel pipe of cold working:	*-E-C*

Table 4.11 Heat Treatment

Grade		Seamless steel pipe		Electric-resistance welded steel pipe		
		Hot finished	Cold finished	As weld	Hot finished	Cold finished
Grade 1	No. 2	As manufactured	Annealing	As weld	As manufactured	Annealing
	No. 3					
Grade 2	No. 2	As manufactured(1)	Low temperature annealing or normalizing	-		
	No. 3	As manufactured(1)	Low temperature annealing or normalizing	-		
	No. 4					
Grade 3	No. 2	As manufactured(1)	Low temperature annealing or normalizing	Low temperature annealing or normalizing	As manufactured(1)	Low temperature annealing or normalizing
	No. 3					
	No. 4			-		
Grade 4	No. 12	Low temperature annealing, isothermal annealing, full annealing, normalizing or normalizing followed by tempering.		-		
	No. 22	Low temperature annealing, isothermal annealing, full annealing or normalizing followed by tempering				
	No. 23	Isothermal annealing, full annealing or normalizing followed by tempering at 650˚C and over		-		
	No. 24					

Note:

1 Low temperature annealing or normalizing may be applied if necessary.

Table 4.12 Chemical Composition

Grade								
		C	Si	Mn	P	S	Cr	Mo
Grade 1	No.2	0.25max	0.35max	0.30-0.90	0.040max	0.040max	-	-
	No.3	0.30max	0.35max	0.30-1.00	0.040max	0.040max	-	-
Grade 2	No.2	0.25max	0.10-0.35	0.30-1.10	0.035max	0.035max	-	-
	No.3	0.30max	0.10-0.35	0.30-1.40	0.035max	0.035max	-	-
	No.4	0.33max	0.10-0.35	0.30-1.50	0.035max	0.035max	-	-
Grade 3	No.2	0.25max	0.10-0.35	0.30-0.90	0.035max	0.035max	-	-
	No.3	0.30max	0.10-0.35	0.30-1.00	0.035max	0.035max	-	-
	No.4	0.33max	0.10-0.35	0.30-1.00	0.035max	0.035max	-	-
Grade 4	No.12	0.10-0.20	0.10-0.50	0.30-0.80	0.035max	0.035max	-	0.45-0.65
	No.22	0.15max	0.50max	0.30-0.60	0.035max	0.035max	0.80-1.25	0.45-0.65
	No.23	0.15max	0.50-1.00	0.30-0.60	0.030max	0.030max	1.00-1.50	0.45-0.65
	No.24	0.15max	0.50max	0.30-0.60	0.030max	0.030max	1.90-2.60	0.87-1.13

Table 4.13 Tensile Test

Grade	Yield point proof stress	Tensile strength (N/mm^2)	Elongation (%) ($L = 5.65\sqrt{A}$)
Grade1 No 2	215 min	370 min	24(20) min
Grade2 No 2			
Grade3 No 2			
Grade1 No 3	245 min	410 min	21(17) min
Grade2 No 3			
Grade3 No 3			
Grade2 No 4	275 min	480 min	19(15) min
Grade3 No 4			
Grade4 No12	205 min	380 min	21(17) min
Grade4 No22	205 min	410 min	21(17) min
Grade4 No23			
Grade4 No24			

Notes:

1 The requirements for elongation given in parentheses in the Table are applied for the case where test specimens are taken transversely. In this case, the test coupon is to be stress relieved at the temperature of 600°C to 650°C after flattened.

2 In case where test specimen of non-tubular section is taken from electric-resistance welded pipes, the test specimen is to be taken from the part that does not include the welded line.

Table 4.14 Bend Test

Grade	Degree of bending	Inside bend radius
1.2 and 3	90°	6 times the outside diameter of pipe

Note:

Electric-resistance welded pipes are to be so bent as the welded line is placed widest.

Fig. 4.3 The position of selection for impact test specimen taken from the seamless steel pipes and other portions than seam of electric resistance welded steel pipes

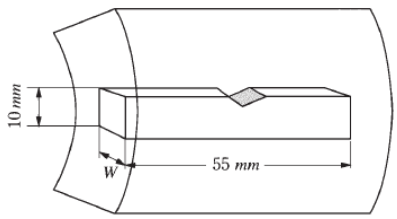


Table 4.15 Value of *e*

Grade	Grade 1 No 3, Grade 2 No 3, Grade 3 No 3, Grade 2 No 4, Grade 3 No 4,	Grade 1 No 2, Grade 2 No 2, Grade 3 No 2, Grade 4 all Nos,
e	0.07	0.08

Table 4.16 Schedule and Hydraulic Test Pressure

Nominal diameter (A)	Outside Diameter (*mm*)	Schedule 10(10S)	Schedule 20(20S)	Schedule 30	Schedule 40	Schedule 60	Schedule 80	Schedule 100	Schedule 120	Schedule 140	Schedule 160
6	10.5	(1.2)	(1.5)	-	1.7	2.2	2.4	-	-	-	-
8	13.8	(1.65)	(2.0)	-	2.2	2.4	3.0	-	-	-	-
10	17.3	(1.65)	(2.0)	-	2.3	2.8	3.2	-	-	-	-
15	21.7	(2.1)	(2.5)	-	2.8	3.2	3.7	-	-	-	4.7
20	27.2	(2.1)	(2.5)	-	2.9	3.4	3.9	-	-	-	5.5
25	34.0	(2.8)	(3.0)	-	3.4	3.9	4.5	-	-	-	6.4
32	42.7	(2.8)	(3.0)	-	3.6	4.5	4.9	-	-	-	6.4
40	48.6	(2.8)	(3.0)	-	3.7	4.5	5.1	-	-	-	7.1
50	60.5	(2.8)	3.2(3.5)	-	3.9	4.9	5.5	-	-	-	8.7
65	76.3	(3.0)	4.5(4.0)	-	5.2	6.0	7.0	-	-	-	9.5
80	89.1	(3.0)	4.5(4.0)	-	5.5	6.6	7.6	-	-	-	11.1
90	101.6	(3.0)	4.5(4.0)	-	5.7	7.0	8.1	-	-	-	12.7
100	114.3	(3.0)	4.9(4.0)	-	6.0	7.1	8.6	-	11.1	-	13.5
125	139.8	(3.4)	5.1(5.0)	-	6.6	8.1	9.5	-	12.7	-	15.9
150	165.2	(3.4)	5.5(5.0)	-	7.1	9.3	11.0	-	14.3	-	18.2
200	216.3	(4.0)	6.4(6.5)	7.0	8.2	10.3	12.7	15.1	18.2	20.6	23.0
250	267.4	(4.0)	6.4(6.5)	7.8	9.3	12.7	15.1	18.1	21.4	25.4	28.6
300	318.5	(4.5)	6.4(6.5)	8.4	10.3	14.3	17.4	21.4	25.4	28.6	33.3
350	355.6	6.4	7.9	9.5	11.1	15.1	19.0	23.8	27.8	31.8	35.7
400	406.4	6.4	7.9	9.5	12.7	16.7	21.4	26.2	30.9	36.5	40.5
450	457.2	6.4	7.9	11.1	14.3	19.0	23.8	29.4	34.9	39.7	45.2
500	508.0	6.4	9.5	12.7	15.1	20.6	26.2	32.5	38.1	44.4	50.0
550	558.8	6.4	9.5	12.7	15.9	22.2	28.6	34.9	41.3	47.6	54.0
600	609.4	6.4	9.5	14.3	17.5	24.6	31.0	38.9	46.0	52.4	59.5
650	660.4	7.9	12.7	-	18.9	26.4	34.0	41.6	49.1	56.6	64.2
Hydraulic test pressure (MPa)		2.0	3.5	5.0	6.0	9.0	12	15	18	20	20

Note:

The values of nominal thickness in parentheses are applicable to stainless steel pipes.

4.2.6 Selection of Test Specimen

The test specimens are to be taken in accordance with the following requirements, from each grade and each size which was heat treated at the same time for heat treated pipes, and from each grade and each size for non-heat-treated pipes, respectively.

(1) Grade 1

One sampling pipe is to be selected from each lot given in **Table 4.17**, and each one specimen for tensile test and flattening test is to be taken from each sampling pipe. As for pipes of 50 *mm* and under in outside diameter, the specimen for flattening test may be substituted for that for bend test.

(2) Grades 2 and 3

One sampling pipe is to be selected from each lot of 50 pipes or fraction thereof, and each one specimen for tensile test and flattening test is to be taken from each sampling pipe. As for pipes of 50 *mm* and under in outside diameter, the specimen for flattening test may be substituted for that for bend test.

(3) Grade 4

One sampling pipe is to be selected from each lot of 50 pipes of fraction thereof, and each one specimen for tensile test and flattening test is to be taken from each sampling pipe.

(4) Tensile test specimen is to comply with the requirements specified in **Table 2.1**.

Table 4.17 Number of Sampling Pipe

Outside diameter D (mm)	Number of sampling pipe
D<70	One pipe for each lot 1000 pipes or fraction thereof
70≤ D ≤ 160	One pipe for each lot of 500 pipes or fraction thereof
160 ≤ D < 350	One pipe for each lot of 250 pipes or fraction thereof
D ≥ 350	One pipe for each lot of 150 pipes or fraction thereof

4.2.7 Tolerances for Dimensions of Pipes

The tolerances for the outside diameter and the thickness are to be in accordance with the requirements in **Table 4.18**.

Table 4.18 Tolerances for Dimensions (1)

Kind	Outside diameter D (mm)	Tolerance for outside diameter	Tolerance for wall thickness			
			Grade 1		Grade 2, 3 and 4	
Hot finished seamless steel pipe	D<50	± 0.5 mm	Thickness of pipe:t (mm) t < 4	+0.6mm -0.5mm	Thickness of pipe:t (mm) t<4	±0.5 mm
	50≤ D ≤ 160	±1%	Thickness of pipe:t (mm) t ≥ 4	+15% -12.5%	Thickness of pipe:t (mm) t ≥ 4	+12.5%
	160 ≤ D < 200	± 1.6 mm				
	D ≥ 200	± 0.8% (2)				
Cold finished seamless steel pipe and electric-resistance welded steel pipe	D<40	± 0.3 mm	Thickness of pipe:t (mm) t<3	±0.3mm	Thickness of pipe:t (mm) t<2	±0.2 mm
	D ≥ 40	± 0.8% (2)	Thickness of pipe:t (mm) t ≥ 3	±10%	Thickness of pipe:t (mm) t ≥ 3	+10%

Notes:

1 For hot finished seamless steel pipes Grades 2, 3 and 4, the tolerance for deviation in wall thickness is to be 20% of the thickness of the pipes and under. However, for pipes less than 5.6 *mm* in wall thickness, this note is not applied.

2 For pipes of 350 *mm* and over in outside diameter, length of circumstances may substitute as a basis for tolerance for outside diameter. In this case, the tolerance is to be ± 0.5%.

4.2.8 Quality

The steel pipes are to be of uniform quality and free from harmful defects.

4.2.9 Marking

The name or brand of the manufacturer, symbol of grade, symbol of the method of manufacture and size are to be legibly stamped or stencilled before shipping on each length pipe of 60 *mm* or over in outside diameter and on each bundle of pipes less than 60 *mm* in outside diameter. The Society's brand indicating compliance with the requirements is to be stamped in the vicinity of the foregoing marks.

4.3 Stainless Steel Pipes

4.3.1 Application

The requirements apply to the stainless steel pipes for low temperature service or corrosion-resistance service (hereinafter referred to as stainless steel pipes in 4.3).

Stainless steel pipes having characteristics differing from those specified in 4.3 are to comply with the requirements in 1.1.1-2.

4.3.2 Kinds

The stainless steel pipes are classified into 10 grades as specified in Table 4.19.

4.3.3 Heat Treatment

The stainless steel pipes are generally to receive a solid solution treatment.

4.3.4 Chemical Composition

The chemical composition of stainless steel pipes is to comply with the requirements given in Table 4.19.

Table 4.19 Grades and Chemical Composition

Grade	Chemical composition (%)								
	C	*Si*	*Mn*	*P*	*S*	*Ni*	*Cr*	*Mo*	Others
K304TP	0.08 max	1.00 max	2.00 max	0.040 max	0.030 max	8.00-11.00	18.00-20.00	-	-
*K*304*LTP*	0.030 max					9.00-13.00			
*K*309*STP*	0.08 max					12.00-15.00	22.00-24.00		
*K*310*STP*		1.50 max				19.00-22.00	24.00-26.00		
*K*316*TP*		1.00 max				10.00-14.00	16.00-18.00	2.00-3.00	
*K*316*LTP*	0.030 max					12.00-16.00			
*K*317*TP*	0.08 max					11.00-15.00	18.00-20.00	3.00-4.00	
*K*317*LTP*	0.030 max								
*K*321*TP*	0.08 max					9.00-	17.00-		*Ti* ≥ 5 x *C*
*K*329*J1TP*	0.08 max	1.00 max	1.50 max	0.040 max	0.030 max	3.00-6.00	23.00-28.00	1.00-3.00	
*K*329*J3LTP*	0.030 max	1.00 max	1.50 max	0.040 max	0.030 max	4.50-6.50	21.00-24.00	2.50-3.50	*N:*0.08-0.20
*K*329*J4LTP*	0.030 max	1.00 max	1.50 max	0.040 max	0.030 max	5.50-7.50	24.00-26.00	2.50-3.50	*N:*0.08-0.20
*K*347*TP*	max					13.00	19.00		*Nb*≥ 10 x *C*

4.3.5 Mechanical Properties

1. The mechanical properties of stainless steel pipes are to comply with the following requirements:

(1) Tensile test:

The tensile tests of stainless steel pipes are to comply with the requirements given in **Table 4.20.**

(2) Flattening test

Flattening tests are to be carried out in accordance with the requirements in **4.2.5(3)**. Where the requirement is applied, the value of *e* is to be taken as 0.09. For automatic arc welded steel pipes, laser beam welded steel pipes and electric-resistance welded steel pipes of 200 *mm* and over in outside diameter, The guide bend test for welded zone deemed appropriate by the Society may be carried out, instead of flattening test

(3) Hydraulic test:

(a) Pipes are to be hydraulically tested with the pressure specified in **Table 4.21**.

(b) In case where the test pressure higher than prescribed in **(a)** is specified by the purchaser, the test is to be carried out with the specified pressure. In this case, the test pressure need not exceed the pressure calculated by the following formula:

$$P = 2St / D$$

where:

P : Hydraulic test pressure (MPa)

D : Outside diameter of pipe (mm)

t : Thickness of pipe (mm)

S : 60% of the prescribed minimum yield point or proof stress (N/mm^2)

(c) When each pipe is hydraulically tested as a regular during the process of manufacturing at the mill which makes a number of pipes continually, and the results are forwarded to the Surveyor, the test in the presence of the Surveyor may be dispensed with.

(d) A non-destructive test deemed appropriate by the Society may be substituted for the hydraulic test specified in **(a)**.

2. Where deemed necessary by the Society, corrosion-resistance test or impact test may be required in addition to the tests specified in **4.3**.

4.3.6 Selection of Test Specimens

One sampling pipe is to be selected from each lot of 50 pipes which are of the same charge, size and kind and are simultaneously heat treated or fraction thereof, and each one specimen for tensile test and flattening test is to be taken from each sampling pipe. Where, however, guided bend test for welded zone is carried out, each one specimen is to be taken from each 120 *m* of pipe which are of the same charge, size and kind and are simultaneously heat treated or fraction thereof.

Table 4.20 Tensile Test[2][3]

Grade	Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) $(L = 5.65\sqrt{A})$	
			L [1]	T [1]
K304TP	205 min	520 min	26 min	22min
*K*304*LTP*	175 min	480 min		
*K*309*STP*	205 min	520 min		
*K*310*STP*				
*K*316*TP*				
*K*316*LTP*	175 min	480min		
*K*317*TP*	205 min	520 min		
*K*317*LTP*	175 min	480min		
*K*321*TP*	205 min	520 min		
*K*329*J1TP*	390 min	590 min	14 min	10 min
*K*329*J3LTP*	450min	620 min	14 min	10 min
*K*329*J4LTP*	450 min	620 min	14 min	10 min
*K*347*TP*	205 min	520 min	26 min	22 min

Notes:

1 *L* (or *T*) denotes that the longitudinal axis of the test specimen is arranged parallel (or normal) to the final direction of rolling.

2 Where the nominal diameter of stainless steel pipes is 200 *mm* and over, tension test specimens may be taken transversely.

3 Where test specimens of non-tubular section are taken from automatic arc welded steel pipes, laser beam welded steel pipes and electric-resistance welded steel pipes, the test specimens are to be taken from the part that does not include the welded line.

Table 4.21 Hydraulic Test Pressure

Schedule N°	10*S*	20*S*	40	80	120	160
Test pressure (*MPa*)	2.0	3.5	6.0	12	18	20

4.3.7 Tolerances for Dimensions Pipes

The tolerances for outside diameter and wall thickness of pipes are to be in accordance with the requirements given in Table 4.22.

Table 4.22 Tolerances for Outside Diameter and Wall Thickness

Division	Outside diameter D (*mm*)	Tolerance for outside diameter	Thickness of pipe t (*mm*)	Tolerance for wall thickness
Hot finished seamless steel pipe	$D < 50$	± 0.5 *mm*	$t < 4$	± 0.5 *mm*
	$D \geq 50$	± 1 %	$t \geq 4$	± 12.5 %
Cold finished seamless steel pipe, automatic are welded steel pipe, laser beam welded steel	$D < 30$	± 0.3 *mm*	$t < 2$	± 0.2 *mm*
	$D \geq 30$	± 1 %	$t \geq 2$	± 10 %

Note:

For hot finished seamless steel pipes, the tolerance for deviation in wall thickness is to be 20% of the thickness and under.

However, it shall not be applied to the pipes less than 5.6 *mm* in wall thickness.

4.3.8 Quality

The stainless steel pipes are to be of uniform quality and free from harmful defects.

4.3.9 Marking

Marking for stainless steel pipes is to comply with the requirements given in 4.2.9.

4.4 Headers

4.4.1 Application

1. The requirements are to apply to the headers to be used for boilers.

2. Headers having characteristics differing from those specified in 4.4 are to comply with the requirements in 1.1.1-2.

4.4.2 Kinds

The headers are classified into 6 grades as specified in Table 4.23.

Table 4.23 Grades of Headers

Grade	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
Symbol	*KBH*-1	*KBH*-2	*KBH*-3	*KBH*-4	*KBH*-5	*KBH*-6

4.4.3 Heat Treatment

Headers are to be heat treated by annealing or normalizing.

4.4.4 Chemical Composition

Headers are to have the chemical composition given in **Table 4.24**.

4.4.5 Mechanical Properties

Headers are to conform to the following requirements as to mechanical properties:

(1) Tensile test:

Headers are to be subjected to tensile test and to conform to the requirements given in **Table 4.25**.

(2) Bend test

The test specimen is to stand being bent cold through 180°without flaw and cracking on the outside of bent portion to an inside radius of 12 *mm*. Where the test specimen of 20 *mm* in thickness cannot be taken, the test specimen may be as original in thickness, in which case, however, the width of test specimen is not to be less than 1.5 times the thickness and the inside radius of bend is to be equal to the thickness.

Table 4.24 Chemical Composition

Grade	Symbol	Chemical composition (%)						
		C	*Si*	*Mn*	*P*	*S*	*Cr*	*Mo*
Grade 1	*KBH*-1	0.25max	0.10-0.35	0.30-0.80	0.040max	0.040max	-	-
Grade 2	*KBH*-2	0.30max	0.10-0.35	0.30-0.80	0.040max	0.040max	-	-
Grade 3	*KBH*-3	0.10-0.20	0.10-0.50	0.30-0.80	0.030max	0.040max	-	0.45-0.65
Grade 4	*KBH*-4	0.10-0.20	0.10-0.50	0.30-0.60	0.030max	0.030max	0.80-1.20	0.20-0.45
Grade 5	*KBH*-5	0.15max	0.10-0.50	0.30-0.60	0.030max	0.030max	0.80-1.20	0.45-0.65
Grade 6	*KBH*-6	0.15max	0.10-0.50	0.30-0.50	0.030max	0.030max	2.00-2.50	0.90-1.10

Table 4.25 Tensile Test

Grade	Symbol	Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) ($L = 5.65\sqrt{A}$)	Reduction of area (%)
Grade 1	*KBH*-1	205 min	410 min	24 min	38 min
Grade 2	*KBH*-1	225 min	450 min	23 min	40 min
Grade 3	*KBH*-1	205 min	380 min	22 min	40 min
Grade 4	*KBH*-1	205 min	410 min	21 min	40 min
Grade 5	*KBH*-1	205 min	410 min	21 min	40 min
Grade 6	*KBH*-1	205 min	410 min	21 min	40 min

Note:

When test specimens are taken at right angle to the direction of rolling, the values of yield point and tensile strength are to be as given in the above Table and the elongation is to take the value reduced by 5% from the percentage given in the above Table. The value of reduction of area may be only remained on records for reference.

4.4.6 Selection of Test Specimen

1. Tensile test specimens are to be taken lengthwise or crosswise to the direction of rolling and bend test specimens to be taken at right angle to the direction of rolling from the open ends of headers respectively.

2. For the headers of the same size made from the same melt and subjected to the heat treatment simultaneously in the same furnace, tensile and bend test specimens are to be selected in accordance with the requirements given in **Table 4.26**.

3. Where the both ends of header are closed by reforging, the test coupons of proper size may be cut from the open ends before reforging. In this case, the test coupons are to be heat treated simultaneously with the body in the same furnace.

4. Where test coupons cut from circular headers, etc. are necessary to be flattened, the test coupons are to be taken from the body before being subjected to the heat treatment and after flattening the test coupons are to be heat treated simultaneously with the body in the same furnace, or the test coupons are to be cut from the structures after being subjected to the heat treatment and after flattened cold, they are to be heated to the temperature of 600°C to 650°C for the purpose of removing the distortion due to the flattening, and the required test specimens are to be cut from the coupons.

5. Tensile and bend test specimens are to comply with the requirements specified in **Tables 2.1** and **2.4** respectively.

Table 4.26 Number of Test Specimens

Grade	Number of test specimens
Grade 1& Grade 2	1 set for each one length: 3,000 mm and over in length 1 set for each three lengths: 2,000 mm and over up to 3,000 mm in length 1 set for each five length: 2,000 mm and over in length
Grade 3 to Grade 6	1 set from each end for each one length: 3,000 mm and over in length 1 set for each one length: Less than 3,000 mm in length

4.4.7 Tolerance for Thickness

The tolerance for thickness is to be ±12.5%. The tolerance, however, may not apply to the closed portions of headers on circular or square section, the side corners of square headers and the corrugated headers.

4.4.8 Quality

The headers are to be of uniform quality and free from harmful defects.

4.4.9 Marking

Marking for headers is generally to comply with the requirements given in 4.1.9.

4.5 Steel Pipes for Low Temperature Service

4.5.1 Application

The requirements are to apply to the seamless steel pipes and electric resistance welded steel pipes not exceeding 25 *mm* in thickness, intended to be used at the design temperature lower than 0°C in liquefied gas carriers (hereinafter referred to as steel pipes in 4.5).

Any requirement regarding the steel pipes over 25 *mm* in thickness is left to the discretion of the Society.

Steel pipes having characteristics differing from these specified in 4.5 are to comply with the requirements in 1.1.1-2.

4.5.2 Kinds

The steel pipes are classified into 6 grades as given in Table 4.27.

4.5.3 Deoxidation Practice and Chemical Composition

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in Table 4.27

Table 4.27 Grades and Chemical Compositions (%)

Grade	Deoxidation	*C*	*Si*	*Mn*	*P*	*S*	*Ni*
KLPA	Fully filled fine grain	0.25 max	0.35 max	1.35 max	0.035 max	0.035 max	-
KLPB		0.18 max	0.35 max	1.60 max	0.035 max	0.035 max	-
KLPC		0.18 max	0.35 max	1.60 max	0.035 max	0.035 max	-
*KLP*2		0.19 max	0.10-0.35	0.90 max	0.035 max	0.035 max	2.00-2.60
*KLP*3		0.18 max	0.10-0.35	0.30-0.60	0.030 max	0.030max	3.20-3.80
*KLP*9		0.13 max	0.10-0.35	0.90 max	0.030 max	0.030 max	8.50-9.50

Note:

Other alloying elements than those given in the above table may be added if necessary.

4.5.4 Heat Treatment

The steel pipes are to be heat treated in accordance with the requirements in **Table 4.28**.

4.5.5 Mechanical Properties

1. The steel pipes are to comply with the following requirements as to mechanical properties:

(1) Tensile test

The steel pipes are to be subjected to tensile test and to comply with the requirements in **Table 4.28**.

(2) Impact test

The steel pipes are to be subjected to impact test and to comply with the requirements in **Table 4.28**.

(3) Flattening test

Flattening test is to be carried out in accordance with the requirement given in **4.2.5(3)**. Where these requirements applied, the value of e is to be taken as 0.08.

For steel pipes of 50 *mm* and under in outside diameter, bend test specified in below may be substituted for flattening test.

Bend test: Test specimen of tubular section which is taken from the end of the pipe and has sufficient length is to stand being bent cold, up to the specified value in **Table 4.28**, without flaw and cracking on the wall.

Moreover, electric resistance welded pipes are to be bent in such a way that the welded line is placed on the outside of bent portion.

(4) Hydraulic test

All steel pipes are to be subjected to hydraulic test in accordance with the requirements given in **4.2.5(4)**.

2. Where deemed necessary by the Society, other tests may be required in addition to the tests specified in **-1**.

Table 4.28 Heat Treatment and Mechanical Properties

Grade	Heat treatment	Tensile test [1][2][3]				Bend test		Impact test	
		Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) ($L = 5.65\sqrt{A}$)		Inside radius of bend	Angle of bend(°)	Testing temp (°C)	Mean absorbed energy (J) [4]
				L	*T*				
KLPA	Normalized, normalized followed by tempering or quenched and tempered	205 min	380 min	26 min	19 min	6 times the outside diameter of pipe	90	-40 [5]	27
KLPB								-50 [5]	
KLPC								-60 [5]	
KLP2		245 min	450 min	20 min	14 min			-70	34
KLP3								-95	
KLP9	Double normalized followed by tempering or quenched and tempered	520 min	690 min	15 min	11 min			-196	41

Notes:

1 *L* (or *T*) denotes that the longitudinal axis of the test specimen is arranged parallel (or normal) to the final direction of rolling.

2 Where the nominal diameter of steel pipes is 200 *mm* and over, the tensile test specimen may be taken transversely.

3 Where test specimen of non-tubular section is taken from electric resistance welded pipes, the test specimen is to be taken from the part that does not include the welded line.

4 Where absorbed energy of more than one of a set of test specimens is under the required minimum mean absorbed energy, or where the absorbed energy of one test specimen is under 70% of the required value, the test is considered to be failed.

5 Impact test temperature for steel pipes specified in *IGC Code IMO* is to be 5°C below the design temperature or -20°C, whichever is the lower.

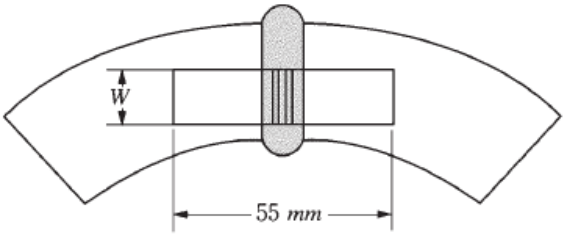
4.5.6 Selection of Test Specimens

1. One sampling pipe is to be selected from each lot of 50 pipes or fraction thereof which are of the same charge, size and kind and are simultaneously heat treated.

2. Each one specimen for tensile test and flattening test (or bend test) is to be taken from each sample pipe. Tensile test specimens are to comply with the requirements specified in **Table 2.1**.

3. One set of three specimens for impact test is to be taken from each sample pipe in accordance with **Fig. 4.3**. Moreover, for electric resistance welded pipes, another set of three specimens is to be taken from the welded zone in accordance with **Fig. 4.4**. Impact test specimens are to comply with the requirements specified in **Table 2.5**.

Fig. 4.4 The position of selection for impact test specimen taken from the weld zone of electric resistance welded steel pipes



4.5.7 Dimensional Tolerance

The tolerances for outside diameter and wall thickness of steel pipes are to be in accordance with the requirements given in **Table 4.29**.

Table 4.29 Tolerances for Outside Diameter and Wall Thickness (1)

Division	Outside diameter D (*mm*)	Tolerance for outside diameter	Tolerance for wall thickness
Hot finished seamless steel pipe	$D < 50$	± 0.5 *mm*	$t < 4$ mm: ±0.5 *mm* $t \geq 4$ *mm* : ± 12.5 %
	$50 \leq D < 160$	± 1%	
	$160 \leq D < 200$	± 1.6 *mm*	
	$D \geq 200$	± 0.8 % (2)	
Cold finished seamless steel pipe and electric-resistance welded steel pipe	$D < 40$	± 0.3 *mm*	$t < 2$ mm: ±0.2 *mm* $t \geq 2$ *mm* : ± 10 %
	$D \geq 40$	± 0.8 % (2)	

Notes:

1 For hot finished seamless steel pipes, the tolerance for deviation in wall thickness is to be 20% of the thickness and under. However, it shall not be applied to the pipes less than 5.6 *mm* in wall thickness.

2 For pipes of 350 *mm* and over in outside diameter, length of circumstances may substitute as a basis for tolerance for outside diameter. In this case, the tolerance is to be ±0.5%.

4.5.8 Quality

The steel pipes are to be of uniform quality and free from harmful defects.

4.5.9 Additional Tests before Rejection

1. Where other mechanical tests than impact tests from the first test specimens selected fail to meet the requirements, additional tests may be carried out according to the requirements given in **1.4.4**.

2. Regarding the impact tests, additional tests are to be carried out according to the requirements given in **3.1.10-3**.

4.5.10 Marking

Marking for steel pipes is generally to comply with the requirements given in **4.2.9** and in case the requirement in **Note (5)** of **Table 4.28** has been applied, "*T*" is to be suffixed to the marking. (Example: *KLPA*-25*T*)

Chapter 5 CASTINGS

5.1 Steel Castings

5.1.1 Application

1. The requirements of 5.1 are to apply to the steel castings intended to be used for the components specified in parts of hull construction, equipment, and machinery, except that of defined in 5.2, 5.3 and 5.5.

2. Steel castings having characteristics differing from those specified in 5.1 are to comply with the requirements in 1.1.1-2.

5.1.2 Manufacturing Process

1. Flame cutting or scarfing to remove risers and surplus metals is to be completed before final heat treatment of the steel castings. Preheating is to be carried out when judged necessary in consideration of the chemical composition and size of the steel castings.

2. Where steel castings are built up by welding, the welding procedure is to be submitted to the Society before the work. In this case, the Society may request to carry out the welding procedure qualification test.

3. Steel castings may be repaired by welding in accordance with the requirements specified in 5.1.11 after obtaining approval of the Surveyor.

4. Where the surface of steel castings is subjected to hardening process by induction hardening, nitrising, cold rolling or other methods, an approval from the Society is to be obtained.

5.1.3 Kinds

The steel castings are classified as specified in Table 5.2.

5.1.4 Chemical Composition

1. Steel castings are to have the chemical composition given in Table 5.1

2. For carbon steel castings intended for welded construction, the carbon content is generally not to exceed 0.23%.

For carbon steel castings complying with this requirements, "*W*" is to be suffixed to the markings.

3. Suitable grain refining elements such as aluminium may be added at the discretion of the manufacturer.

4. The manufacturer is to make an analysis of each melt in ladles (When multiple heats are tapped into a common ladle, the ladle analysis is to apply.) and the results are to be reported to the Surveyor.

Table 5.1 Chemical Composition

Kind	Chemical composition (%)										
	C	Si	Mn	S	P	Cu	Cr	Ni	Mo	W	Total residual elements
Carbon steel castings	0.40 max	0.60 max	0.50 - 1.60	0.040 max	0.040 max	0.30 max (1)	0.30 max (1)	0.40 max (1)	0.15 max (1)	-	0.80 max
Low alloy steel castings	0.25 max	0.60 max	0.50 - 0.80	0.030 max	0.030 max	0.50 max (1)	0.30 - 1.50 (2)	0.50 max (1)	0.15- 1.20 (2)	0.10 max (1)	1.00 max

Notes:

1 Elements are considered as residual elements. Residual elements are not to be intentionally added to the steel.

2 One or more of the elements is to comply with the minimum content.

5.1.5 Heat Treatment

1. For ensuring greater grain refining of the metal crystal, better removal of residual stresses and required mechanical properties, steel castings are to be annealed, normalized, normalized and tempered, or quenched and tempered at proper stages of manufacturing process. The annealing temperature is to exceed 550°C.

2. Steel castings, which were locally heated or subjected to any cold work after heat treatment, are to be stress-relieved by the approved methods. Castings for components such as crankshafts and engine bedplates, where dimensional stability and freedom from internal stresses are important, are to be given a stress relief heat treatment.

This is to be carried out at a temperature of not less than 550 °C followed by furnace cooling to 300 °C or lower.

3. The furnace intended to be used for heat treatment is to have sufficient size for uniform heating of the steel castings to the required temperature. The furnace is to be equipped with a device capable of regulating and recording the furnace temperature.

4. Sufficient thermocouples are to be connected to the furnace charge to measure and record that its temperature is adequately uniform unless the temperature uniformity of the furnace is verified at regular intervals.

5. The foundry is to maintain records of heat treatment identifying the furnace used, furnace charge, date, temperature and time at temperature.

5.1.6 Mechanical Properties

1. The mechanical properties of the steel castings are to conform to the requirements given in **Table 5.2**.

2. Intermediate values of those tabulated in **Table 5.2** may be applicable where approval of the Society is obtained. In this case, the values are to be obtained by interpolation and counting fractions over 0.5 as one and disregarding the rest.

Table 5.2 Mechanical Properties of Steel Castings

Kind	Grade	Tensile strength (N/mm^2)	Yield point or proof stress (N/mm^2)	Elongation (%) ($L = 5.65\sqrt{A}$)	Reduction of area (%)
Carbon Steel castings	*KSC*42	410 min	205 min	24 min	38 min
	*KSC*46	450 min	225 min	22 min	29 min
	*KSC*49	480 min	240 min	20 min	27 min
	*KSC*53	520 min	260 min	18 min	25 min
	*KSC*57	560 min	300 min	15 min	20 min
	*KSC*61	600 min	320 min	13 min	20 min
Low alloy steel castings	*KSC*45	440 min	245 min	22 min	40 min
	*KSC*49	480 min	275 min	17 min	35 min
	*KSC*56	550 min	340 min	16 min	35 min

5.1.7 Mechanical Tests

1. Mechanical tests for the steel castings are to be carried out in accordance with the requirements specified in **Chapter 2**.

2. Where the tensile tests from the first test specimens selected fail to meet the requirements, additional tests may be conducted according to the requirements given in **1.4.4**.

5.1.8 Selection of Test Specimens

1. The test specimens for steel castings are, after final heat treatment, to be taken from the test assembly cast integral with the body of casting.

2. The number of test specimens is to be as given in **(1)** through **(4)** of the following requirements:

(1) Except where otherwise specifically specified by the Society, one tensile test specimen is to be taken from each steel casting. In case where the mass of one steel casting (as heat treated, hereinafter referred to as the mass) is more than ten tons, two test specimens are to be taken from each steel casting.

(2) In case where the mass of one casting is one ton and less than one test specimen is to be taken from every one group of steel castings cast from the same charge and heat treated simultaneously in the same

furnace. In case where the total mass of one group of steel casting exceeds two tons, two test specimens are to be taken.

(3) In case where a number of steel castings of similar form and size are cast from the same charge and each mass for the castings is less than 500 *kg*, test coupons may be separately cast under the Surveyor s approval regardless of the requirements in **1** and **2** above. In this case, one test specimen is to be taken from the test coupon which is heat treated simultaneously with the body of the steel casting in the same furnace.

(4) In case where one steel casting is made from two or more casts, which are not mixed in a ladle prior to pouring, one tensile test specimen is to be taken from each charge regardless of the requirements in **(1)** or **(2)** above.

3. The test specimens are to be taken from test assembly having a thickness of not less than 30 *mm*.

5.1.9 Surface Inspection and Dimension Inspection

1. When heat treatment and machining are finished and, if necessary, at a proper stage during machining, surface inspection is to be carried out.

2. The steel castings are not to be subjected to any treatment such as painting, which is harmful for inspection before the surface inspection.

3. The dimension inspection of the steel castings is to be conducted under the responsibility of the manufacturer.

5.1.10 Non-destructive Testing

1 The steel castings are to be subjected to non-destructive testing in accordance with **(1)** and **(2)** of the following requirements:

(1) Ultrasonic test

(a) The steel castings intended for stern frame, rudder frame and other important hull structural members and required for ultrasonic test as specified in **2.2.1-1, Part 7** are to be subjected to ultrasonic tests at an appropriate stage of the manufacturing process and the test reports are to be showed or submitted to the Surveyor.

(b) Performance of ultrasonic testing apparatus is to be of good efficiency for testing of large steel castings.

(c) Operator engage in the ultrasonic tests is to have a sufficient technique and experience for the testing of steel castings.

(2) Magnetic particle test

The important parts of the following steel castings are to be subjected to magnetic particle tests at an appropriate stage of the manufacturing process. But, machining surfaces may be subjected to liquid penetrant tests.

(a) Steel castings intended for stern frame, rudder frame and other important hull structural members

(b) Steel castings required for magnetic particle test or liquid penetrant test specified in **2.2.1-1, Part 7**

(c) Propellers

(d) Turbine casings

2. In place of the test methods given in **-1**, the Society may accept the application of other non-destructive testing considered adequate by the Society.

3. The society may require non-destructive inspections by radiographic test, ultrasonic test, magnetic particle test or liquid penetrant test not only for the steel castings specified in **-1** but also for the steel castings deemed necessary by the society.

4. The welding parts of steel castings used for welded construction are to be subjected to non-destructive inspections considered adequate by the Society.

5.1.11 Repair of Defects

1. In the event of finding defects considered harmful for the intended use in the steel casting, the defects are to be removed by a grinder, etc.

2. After removing the defects, magnetic particle test or liquid penetrant test is to be carried out to ensure that all defects have been completely removed.

3. Where the steel castings from which defects were removed are used in that condition, an approval of the Surveyor is to be obtained for confirming the adequacy. The steel castings from which defects were removed may be permitted the use without weld repairs provided that they will cause no appreciable reduction in the strength of the casting. The portions of removed of defect are to be finished smoothly for avoiding stress concentration.

4. Where the steel castings from which defects were removed repaired by welding, an approval of the Surveyor is to be obtained in advance as to the scope of repairs, welding and heat treatment. The Society may request the test to confirm the mechanical properties at the portion of welded repair.

5. The portions repaired by welding are to be confirmed that they are free from harmful defects by adequate non-destructive testing.

6. The manufacturer is to present full records detailing the extent and location of repairs made to each casting and details of weld procedures and heat treatments applied for repairs, to the Surveyor on request.

5.1.12 Marking

1. Steel castings which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **1.5.1**. For steel castings to which the requirements given in **5.1.6-2** have been applied, the value corresponding to the required tensile strength employed is to be used to the grade mark. (ex. Where the required tensile strength employed is 430 N/mm^2, *KSC*44 is to be indicated)

2. The grade of material and the manufacturer s name or trade mark are to be cast or stamped on all cast steels. In addition, cast number and test number are to be stamped on all cast steels greater than 250kg in

weight. The Society's brand indicating satisfactory compliance with the Rule requirements is to be stamped on all cast steels in the neighbourhood of the above mentioned marks.

5.1.13 Additional Requirements for Crank Throws

1. In case where semi-built-up crank throws for diesel engines are made of steel castings, the manufacturing procedure is to be approved by the Society.

2. Where the manufacturing processes using the surface treatments are adopted to reduce the size of crank throw according to the requirements in 2.3.1-1, Part 7, the preliminary tests instructed by the Society are to be carried out.

5.2 Steel Castings for Chains

5.2.1 Application

1. The Requirements are to apply to the steel castings intended to be used for link of Grades 2 and 3 chains and shackle, swivel, etc. of all grades chains except Grade 1 chains specified in Part 5 (hereinafter referred to as steel castings in 5.2).

2. Steel castings having characteristics differing from those specified in 5.2 are to comply with the requirements in 1.1.1-2.

5.2.2 Kinds

The steel castings are classified into 5 grades as specified in Table 5.3

Table 5.3 Grades of Steel Castings

Grades		Application
Grade 2 steel casting	*KSCC*50	Grade 2 chain
Grade 3 steel casting	*KSCC*70	Grade 3 chain
Grade *R*3 steel casting	*KSCCR*3	Grade *R*3 chain
Grade *R*3*S* steel casting	*KSCCR*3*S*	Grade *R*3*S* chain
Grade *R*4 steel casting	*KSCCR*4	Grade *R*4 chain
Grade *R*4*S* steel casting	*KSCCR*4*S*	Grade *R*4*S* chain
Grade *R*5 steel casting	*KSCCR*5	Grade *R*5 chain

5.2.3 Heat Treatment

1. Steel castings are to be normalized, normalized and tempered, quenched and tempered or heat treated by the process approved by the Society.

2. Steel castings which are locally heated or subjected to any cold work after heat treatment, are to be stress-relieved by the approved methods.

3. Flame cutting or scarfing to remove risers and surplus metals is to be completed before final heat treatment of the steel castings.

5.2.4 Chemical Composition

The chemical composition of steel castings is to be subjected to the special approval by the Society.

5.2.5 Mechanical Properties

1. The mechanical properties of steel castings are to comply with the requirements specified in **Table 5.4**.

Table 5.4 Mechanical Properties

Grade	Tensile test				Impact test(1)	
	Yield point or proof stress(2) (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) (L=5 d)	Reduction of area (%)	Testing temperature (°C)	Minimum mean absorbed energy (J)
*KSCC*50	295 min	490-690	22 min	-	0(3)	27(3)
*KSCC*70	410 min	690 min	17 min	40 min	0	60
*KSCCR*3	410 min	690 min	17 min	40 min	-20(4)	40(4)
*KSCCR*3*S*	490 min	770 min	15 min	40 min	-20(4)	45(4)
*KSCCR*4	580 min	860 min	12 min	35 min	-20	50
*KSBCR*4S	700 min	960 min	12 min	35 min	-20	56
*KSBCR*5	760 min	1000 min	12 min	35 min	-20	58

Notes:

1 When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified minimum mean absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified minimum mean absorbed energy, the test is considered to have failed.

2 Aim value of yield to tensile ratio for grades *KSCCR*3, *KSCCR*3*S, KSCCR*4, *KSBCR*4*S* and *KSBCR*5 is to be maximum 0.92.

3 Impact test is only required for accessories, enlarged links and end links made by casting excluding enlarged links and end links which are connected to chains made by casting and are made therewith.

4 Impact test of grade *KSCCR*3 and *KSCCR*3*S* may be carried out at the temperature of 0°C where approved by the Society. In this case, minimum mean absorbed energy is to be not less than 60*J* for grade *KSCCR*3 and 65*J* for grade *KSCCR*3*S*.

5.2.6 Selection of Test Specimen

1. One test sample is to be taken from castings of similar dimensions originating from the same heat treatment charge and the same cast of steel. In this case, the test sample may be the test assembly cast with the body of casting and similar area.

2. One tensile test specimen and one set (3 pieces) of impact test specimens are to be taken from the test sample specified in **-1** above. However, for Grade 2 steel castings to be not required carrying out impact test according to **Note (4)** of **Table 5.4**, impact test specimens need not to be taken.

3. The tensile and impact test specimens are to be taken from the test sample in the longitudinal direction at a depth of 1/6 diameter from the surface or as close as possible to this position (*See* **Fig. 3.2**).

4. The tensile and the impact test specimens are to comply with the requirements specified in **Table 2.1** and **2.5** respectively.

5.2.7 Surface Inspection

After the heat treatment of steel castings is finished, surface inspection is to be carried out.

5.2.8 Quality

Steel castings are to be of uniform quality and free from harmful defects.

5.2.9 Non-destructive Test

1. For grades *KSCCR*3, *KSCCR*3S and *KSCCR*4, *KSBCR*4*S* and *KSBCR*5, all steel castings are subjected to ultrasonic examination at an appropriate stage of the manufacture and it is to be confirmed that there is no harmful defect.

2. For grades *KSCC*50 and *KSCC*70, a suitable non-destructive test such as an ultrasonic examination may be required where deemed necessary by the Society.

5.2.10 Repair of Defects

Repair of defects for steel castings is generally to be carried out in accordance with the requirements specified in **5.1.11**.

5.2.11 Additional Tests before Rejection

Where the tensile test or impact test on the selected first test specimens fails to meet the requirements, additional tests may be conducted according to the requirements given in **3.6.9**.

5.2.12 Marking

Steel castings which have satisfactorily complied with the required tests are to be marked with identification mark in accordance with the requirements in **5.1.12**.

5.3 Stainless Steel Castings

5.3.1 Application

1. The requirements are to apply to the stainless steel castings for valves and pipe fittings in piping systems used at low temperature (-165°C and over in design temperature) service or corrosion-resisting service (hereinafter referred to as "steel castings" in 5.3).

2. Steel castings having characteristics differing from those specified in 5.3 are to comply with the requirements in 1.1.1-2.

3. In addition to the requirements given in 5.3, general requirements may be considered by the Society.

5.3.2 Kinds

The steel castings are classified into 7 grades as specified in Table 5.5.

5.3.3 Heat Treatment

The steel castings are generally to receive a solid solution treatment.

5.3.4 Chemical Composition

The chemical composition of stainless steel castings is to comply with the requirements given in Table 5.5.

Table 5.5 Grades and Chemical Composition of Stainless Steel Castings

Grade		Chemical composition (%)							
	C	*Si*	*Mn*	*P*	*S*	*Ni*	*Cr*	*Mo*	Others
*KSCS*13	0.08 max.	2.00 max.	2.00 max	0.040 max.	0.030 max.	8.00-11.00	18.00-21.00	-	-
*KSCS*14	0.08 max.	1.50 max	2.00 max	0.040 max.	0.030 max.	10.00-14.00	17.00-20.00	2.00-3.00	-
*KSCS*16	0.030 max.	1.50 max	2.00 max	0.040 max.	0.030 max.	12.00-16.00	17.00-20.00	2.00-3.00	-
*KSCS*17	0.08 max	2.00 max	2.00 max	0.040 max.	0.030 max.	12.00-15.00	22.00-26.00	-	-
*KSCS*18	0.08 max.	2.00 max	2.00 max	0.040 max.	0.030 max.	19.00-22.00	23.00-27.00	-	-
*KSCS*19	0.030 max.	2.00 max	2.00 max	0.040 max.	0.030 max.	8.00-12.00	17.00-21.00	-	-
*KSCS*21	0.08 max.	2.00 max	2.00 max	0.040 max.	0.030 max.	9.00-12.00	18.00-21.00	$1.35 \geq Nb+Ta \geq 10xC$	

5.3.5 Mechanical Properties

1. The mechanical properties in tensile tests and hardness tests are to comply with the requirements given in Table 5.6.

2. Where deemed necessary by the Society, other tests on notch toughness or corrosion-resistance may be required in addition to the specified tests.

Table 5.6 Mechanical Properties of Stainless Steel Castings

Grade	Tensile test			Hardness
	Proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) (L=5.65$\sqrt{A}$)	H_B
*KSCS*13	185 min	440 min	26 min	183 max
*KSCS*14	185 min	440 min	26 min	
KSCS16	175 min	390 min	31 min	
KSCS17	205 min	440 min	26 min	
KSCS18	185 min	440 min	26 min	
KSCS19	185 min	390 min	31 min	
KSCS21	205 min	440 min	26 min	

5.3.6 Selection of Test Specimens

1. Where a stainless steel casting is 500kg and over in mass, one tensile test specimen and one hardness test specimen are to be taken from each casting.

2. Where a number of stainless steel castings of similar form and size, each of which mass less than 500kg, are cast from the same charge, two tensile test specimens and two hardness test specimens are to be taken from each group of castings simultaneously heat treated in the same furnace.

3. Hardness test specimen may be a portion of tensile test specimen.

4. Tensile test specimen is to comply with the requirements given in **Table 2.1**.

5.4 Steel Castings for Low Temperature Service

5.4.1 Application

1. The requirements are to apply to the steel castings for valves and pipe fittings in piping systems intended to used for low temperature service (hereinafter referred to as steel castings).

2. Steel castings other than specified in **5.4** or those used in other parts than specified in **-1** are to comply with the requirements given in **1.1.1-2**.

3. In addition to the requirements given in **5.4**, general requirements may be considered by the Society.

5.4.2 Kinds

The steel castings are classified into 4 grades as given in **Table 5.7**.

Table 5.7 Grades and Chemical Composition (%)

Grade	Deoxidation	*C*	*Si*	*Mn*	*P*	*S*	*Ni*	*Mo*
KLCA	Fully killed fine grain	0.30 max.	0.60 max.	1.00 max	0.035 max.	0.035 max.	-	-
KLCB		0.25 max.	0.60 max	0.50 -0.80	0.035 max.	0.035 max.	-	0.45-0.65
*KLC*2		0.25 max.	0.60 max	0.50 -0.80	0.030 max.	0.030 max.	2.00-3.00	-
*KLC*3		0.15 max	0.60 max	0.50 -0.80	0.030 max.	0.030 max.	3.00-4.00	-

5.4.3 Heat Treatment

Steel castings are to be normalized or normalized and tempered.

5.4.4 Deoxidation Practice and Chemical Composition

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in **Table 5.7**.

5.4.5 Mechanical Properties

1. The mechanical properties of steel castings are to comply with the requirements given in **Table 5.8.**

2. Where deemed necessary by the Society, other tests may be required in addition to the tests specified in **-1**.

Table 5.8 Mechanical Properties

	Tensile test				Impact test (2)	
Grade	Yield point or proof stress(2) (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) (L=5 d)	Reduction of area (%)	Testing temperature (°C)	Mean absorbed energy (J)
*KLC*A	245 min	450 min	21 min	35 min	-45 (1)	27 min
*KLC*B					-60 (1)	
*KLC*2	275 min				-70	34 min
*KLC*3					-95	

Notes:

1 Impact test temperature for castings specified in *IGC Code IMO* is to be 5°C below the design temperature or -20°C, whichever is the lower.

2 There the absorbed energy of more than one of a set of test specimens is under the required minimum mean absorbed energy, or where the absorbed energy of one test specimens is under 70% of required value, the test is considered to be failed.

5.4.6 Selection of Test Specimens

1. Where a steel casting is 500*kg* and over in mass, one tensile test specimen and one set of three impact test specimens are to be taken from each casting.

2. Where a number of steel castings of similar form and size, each of which mass less than 500 *kg*, are cast from the same charge, two tensile test specimens and two sets of three impact test specimens are to be taken from each group of castings simultaneously heat treated in the same furnace.

3. The size and dimensions of tensile and impact test specimens are to comply with the requirements specified in **Table 2.1** and **Table 2.5** respectively.

5.4.7 Additional Tests before Rejection

1. Where the tensile tests from the first test specimens selected fail to meet the requirements, additional tests may be carried out according to the requirements given in **1.4.4**.

2. Regarding the impact tests, additional tests are to be carried out according to the requirements given in **3.1.10-3.**

5.4.8 Marking

Marking of the steel casting is to comply with the requirements given in **5.1.12** and in case the requirement in **Note (1)** of **Table 5.8** has been applied, "*T*" *is* to be suffixed to the marking.

(Example: *KLCA*-25*T*)

5.5 Gray Iron Castings

5.5.1 Application

1. The requirements in this section are to apply to the gray iron castings (hereinafter referred to as iron castings).

2. Iron castings other than specified in **5.5** are to comply with the requirements given in **1.1.1-2.**

5.5.2 Manufacturing Process

Suitable mechanical methods such as grinding are to be employed for the removal of surplus material from iron castings. Thermal cutting process are not acceptable, except as a preliminary operation to mechanical methods.

5.5.3 Kinds

The iron castings are classified as specified in **Table 5.9**.

Table 5.9 Kinds and Mechanical Properties of Iron castings

Material grade	Tensile strength(1) (N/mm^2)
*KFC*20	200 min
*KFC*25	240 min
*KFC*30	290 min
*KFC*35	340 min

Note:

1 The standards given in this Table are for the test sample taken from iron casting separately cast. Where the test sample cast integral with the casting are used, the standards applied are left to the discretion of the Society.

5.5.4 Chemical Composition

The chemical composition of iron castings is to be suitable to obtain the specified mechanical properties. Where deemed necessary by the Society, the Society may require the manufacturer to carried out an analysis of each melt in ladle.

5.5.5 Heat Treatment

The iron castings may be carried out by appropriate heat treatments if necessary.

5.5.6 Mechanical Properties

1. Mechanical properties of iron castings are to comply with the requirements given in **Table 5.9**.

2. Intermediate value of those tabulated in **Table 5.9** may be applicable where approval of the Society is obtained. In this case, the values are to be obtained by interpolation and counting fractions over 0.5 as one and disregarding the rest.

5.5.7 Mechanical Test

1. Mechanical test for iron castings is tensile test, and is to be carried out in accordance with the requirements given in **Chapter 2**.

2. Where tensile test fails to meet the requirements, retest may be carried out in accordance with the requirements in **1.4.4**. In this case, however, test specimens are to be taken out of other test samples.

5.5.8 Selection of Test Specimens

1. Separately cast test samples of iron casting are to be used.

2. The test samples are to be cast from the same ladle as the one for castings in the moulds of the same type of material as the one for the moulds for the castings and are not to be stripped from the moulds until the

metal Temperature is below 500°C. The test samples are to be in form of bars 30 *mm* in diameter and of a suitable length.

When two or more test samples are cast simultaneously in a single mould, the bars are to be at least 50 *mm* apart from each other. (*See* **Fig. 5.1**)

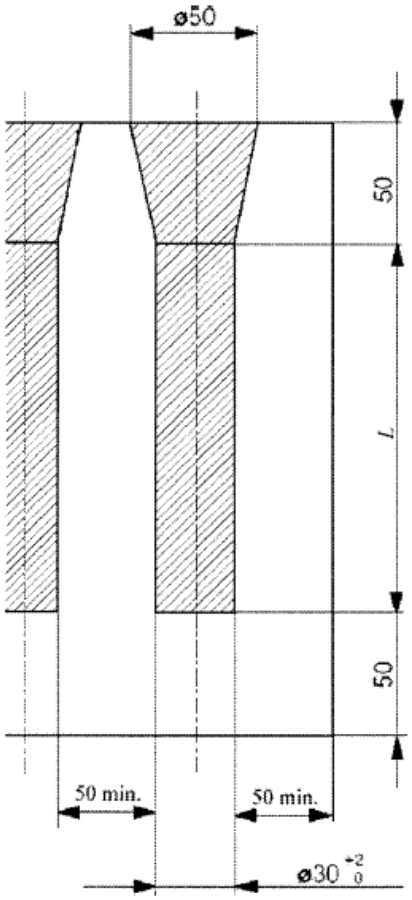
3. One tensile test specimen of iron castings is to be taken from the test samples required by the followings.

(1) Except where otherwise specially specified by the Society, one lot is iron castings whose weight is less than 2 *tons* and consist of the castings poured from a single ladle of metal provided that they are all of similar type and dimensions, and one test sample is to be taken from each one lot. If weight of single iron casting is not less than 2 *tons*, one lot is it, and one test sample is to be taken from each one lot.

(2) Notwithstanding the requirement in **(1)** above, for continuous melting of the same grade of casting steels, one lot is the mass of a batch which may be increased to the output of 2 *hours* of pouring. One test sample is to be taken from each one lot.

(3) Notwithstanding the requirements in **(1)** and **(2)** above, one lot may be taken at longer intervals or from large quantities where approved by the Society.

Fig. 5.1 Shapes of Test Sample (Unit: *mm*)



Note :
L : Parallel part length

5.5.9 Surface Inspection and Dimension Inspection

Surface inspection and dimension inspection are to be carried out in accordance with the requirements in 5.1.9.

5.5.10 Non-destructive Testing

The Society may require non-destructive test for the iron castings if deemed necessary by the Society.

5.5.11 Quality

1. The iron castings are to be free from harmful defects to use.

2. Small surface blemishes are to be removed by local grinding. Subject to the prior approval of the Surveyor, the steel castings containing small porosity may be rectified by a suitable repair process.

3. Repairs by welding are generally not permitted.

5.5.12 Marking

Marking of the iron castings is to follow the requirements in 5.1.12.

5.6 Spheroidal or Nodular Graphite Iron Castings

5.6.1 Application

1. The requirements are to apply to the spherical or nodular graphite iron castings (hereinafter referred to as iron castings).

2. Iron castings other than specified in 5.5 are to comply with the requirements given in 1.1.1-2.

5.6.2 Manufacturing Process

1. Suitable mechanical methods such as grinding are to be employed for the removal of surplus material from iron castings. Thermal cutting process are not acceptable, except as a preliminary operation to mechanical methods.

2. Where the iron castings is subjected to surface hardening process, an approval from the Society is to be obtained.

5.6.3 Kinds

The iron castings are classified as specified in Table 5.10.

Table 5.10 Kinds and Mechanical Properties of Iron castings

Grade	Tensile test			Impact test	
	Tensile strength (N/mm^2)	Proof stress(2) (N/mm^2)	Elongation (%) ($L = 5.65\sqrt{A}$)	Testing temperature (°C)	Minimum mean absorbed energy (J)
*KFCD*37	360	235	17	-	-
*KFCD*40	390	255	12	-	-
*KFCD*45	440	285	10	-	-
*KFCD*50	490	325	7	-	-
*KFCD*60	590	370	3	-	-
*KFCD*70	680	420	2	-	-
*KFCD*80	780	480	2	-	-
*KFCD*36*S*	350	220	22	20	17(14) (3)
*KFCD*41*S*	400	250	18	20	14 (11) (3)

Notes:

1 The standards given in this Table are for the test sample taken from iron casting separately cast. Where the test sample cast integral with the casting are used, the standards applied are left to the discretion of the Society.

2 Proof strength required in the Table are shown for reference.

3 When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified minimum mean absorbed energy or when the absorbed energy of a single test specimen is less in value than shown in brackets in the Table, the test is considered to be failed.

5.6.4 Chemical Composition

1. The chemical composition of iron castings is to be suitable to obtain the specified mechanical properties. Where deemed necessary by the Society, the Society may require the manufacturer to carry out an analysis of each melt in ladle.

2. A dispersed spheroidal or nodular form of graphite is generally to be at least 90 %. The Society may require the confirmation of a dispersed spheroidal or nodular form of graphite if deemed necessary by the Society.

5.6.5 Heat Treatment

Iron castings may be supplied in a suitable heat treatment if necessary. For *KFCD*36*S* and *KFCD*41*S*, fertilizing heat treatment is to undergo.

5.6.6 Mechanical Properties

1. Mechanical properties of iron castings are to comply with the requirements given in **Table 5.10.**

2. Intermediate value of those tabulated in **Table 5.9** may be applicable where approval of the Society is obtained.

In this case, the values are to be obtained by interpolation and counting fractions over 0.5 as 1.0 or disregarding the rest.

5.6.7 Mechanical Tests

1. Mechanical tests of iron castings are the tensile test and the impact test according to the grade of iron castings, and are to be carried out in accordance with the requirements in **Chapter 2**.

2. Where the result of the tensile test is failed, retest may be carried out in accordance with the requirements in **1.4.4**. In this case, test specimens are to be taken from other test samples.

3. Where the result of the impact test is failed, retest may be carried out in accordance with the requirements in **3.1.10-3.** In this case, test specimens are to be taken from other test samples.

5.6.8 Selection of Test Specimens

1. Test specimens of iron castings are to be taken from test samples separately cast.

2. The test samples are to be cast from the same ladle as the one for the castings in the moulds of the same type of material as the one for the moulds for the castings and are not to be stripped from the moulds until the metal temperature is below 500°C. Type and dimensions of test samples are to be deemed appropriate by the Society.

3. One piece of tensile test specimen and one set of impact test specimens of iron castings are to be taken from the following test samples respectively.

(1) Except where otherwise specially specified by the Society, one lot is iron castings whose weight is less than 1 *ton* and consist of the castings poured from a single ladle of metal, provided that they are all of similar type and dimensions, one test sample is to be taken from each one lot. If weight of single iron casting is not less than 2 *tons*, one lot is it, and one test sample is to be taken from each one lot.

(2) Notwithstanding the requirements in **(1)** above, for large castings where more than one ladle of treated metal is used, one test sample is to be taken from each ladle.

5.6.9 Surface Inspection and Dimension Inspection

Surface inspection and dimension inspection are to be carried out in accordance with the requirements in **5.1.9**.

5.6.10 Non-destructive Testing

The Society may require non-destructive testing for the iron castings if deemed necessary by the Society.

5.6.11 Quality

1. The iron castings are to be free from harmful defects to use.

2. Small surface blemishes are to be removed by local grinding. Subject to the prior approval of the Surveyor, the steel castings containing small porosity may be rectified by a suitable repair process.

3. Repairs by welding are generally not permitted.

5.6.12 Marking

Marking of the iron castings is to follow the requirements in **5.1.12**.

5.7 Stainless Steel Propeller Castings

5.7.1 Application

1. The requirements specified in **5.7** apply to the stainless steel castings intended to be used for propellers and propeller blades (hereinafter referred to as steel propeller castings in **5.7**).

2. Steel propeller castings with characteristics differing from those specified in **5.7** are to comply with the requirements in **1.1.1-2**.

5.7.2 Kinds

The steel propeller castings are classified as specified in Table 5.11.

Table 5.11 Kinds and Grades

Kind	Grade
Martensitic stainless steel propeller casting. Grade 1 (12 Cr-1Ni)	*KSCSP*1
Martensitic stainless steel propeller casting. Grade 2 (13 Cr-4Ni)	*KSCSP*2
Martensitic stainless steel propeller casting. Grade 3 (16 Cr-5Ni)	*KSCSP*3
Austenitic stainless steel propeller casting. Grade 4 (19 Cr-11Ni)	*KSCSP*4

5.7.3 Chemical Composition

The chemical composition of steel propeller castings is to comply with the requirements specified in Table 5.12.

5.7.4 Heat Treatment

Martensitic stainless steel propeller castings are to be quenched and tempered. Austenitic stainless steel castings are to be solution treated.

5.7.5 Mechanical Properties

The mechanical properties are to comply with the requirements given in Table 5.13.

Table 5.12 Chemical Composition

Grade	Chemical composition (%)							
	C	*Si*	*Mn*	*P*	*S*	*Ni*	*Cr*	*Mo*
*KSCSP*1	0.15 max	1.0 max	2.0 max	0.040 max	0.030 max	2.0 max	11.5-17.0	0.5 max
*KSCSP*2	0.06 max	1.0 max	2.0 max	0.040 max	0.030 max	3.5-5.0	11.5-17.0	1.0 max
*KSCSP*3	0.06 max	1.0 max	2.0 max	0.040 max	0.030 max	3.5-6.0	15.0-17.5	1.5 max
*KSCSP*4	0.12 max	2.0 max	1.6 max	0.040 max	0.030 max	8.0-13.0	16.0-21.0	4.o max

Table 5.13 Mechanical properties

Grade	Tensile test				Impact test (3)
	0.2% Proof stress ($N/mm2$)	Tensile strength ($N/mm2$)	Elongation (%) (L=5 d)	Reduction of area (%)	Minimum mean absorbed energy (J)
*KSCSP*1	440 min	590 min	15 min(4)	30min	20
*KSCSP*2	550 min	750 min	15 min(4)	35min	30
*KSCSP*3	540 min	760 min	15 min(4)	35min	30
*KSCSP*4	180 min	440 min	30min	40min	20

Notes:

1 The requirements specified in this Table apply to specimens cut from propeller casting itself. Where specimens cut from separately-cast samples, the requirements are to be deemed appropriate by the Society.

2 In case where 1.0% proof stress is applied, the proof stress is not less than 205 N/mm^2.

3 This test is required only for propellers of ships with an ice class notation. The test temperature is to be -10°C. For the judgment of the test, **Note (1)** of **Table 5.4** is to be referred to.

4 For propellers of ships with an ice class notation, the elongation is not to be less than 19%.

5.7.6 Mechanical Tests

1. Tensile test and impact test are to be carried out in compliance with the requirements specified in **Chapter 2** to verify the mechanical properties of steel propeller castings.

2. Where any test results from the first test specimen selected fail to meet the requirements, additional tests may be conducted according to the requirements given in **5.4.7.** The test specimens for the additional tests are to be taken from the same sample from which the first test specimen is taken or from other test samples representative of the steel propeller castings.

5.7.7 Selection of Test Specimens

1. The test specimens for steel propeller castings are to be taken from the integrally cast test samples attached to the propeller castings. The test samples separately cast from the steel propeller castings are subject to the prior approval.

2. The test samples attached on blades are to be located in an area between 0.5 to 0.6R, where R is the radius of the propeller, and not to be detached from the castings until the final heat treatment has been carried out. Removal is to be by non-thermal procedures.

3. At least one test sample is to be made on material representing each steel propeller casting. Where a number of small propellers of about the same size, and less than 1m in diameter, are made from one cast and heat treated in the same furnace charge, a batch testing procedure may be adopted using separately cast test

samples of suitable dimensions. In this case, at least one test sample is to be made for each multiple of five castings in the batch.

4. Mechanical tests are to be carried out with one test specimen and one set of test specimens for tensile test and impact test respectively.

5.7.8 Surface and Dimensional Inspection

1. The steel propeller castings are to be subjected to visual inspection on zone A, B and C shown in Fig. 7.1, in the finished condition. The inspection may also be required at other proper processing stages if necessary.

2. The dimensional inspections of steel propeller castings are to be performed by the manufacturer. Where straightening of a bent blade is carried out, the approval by the Society is to be obtained in advance. The procedure for the straightening is to be deemed appropriate by the Society.

5.7.9 Non-destructive Inspection

1. The steel propeller castings are to be subjected to the penetrant test deemed appropriate by the Society.

2. The ultrasonic or radiographic test is to be required, if deemed necessary by the Society.

5.7.10 Repair of Defects

1. The defects which would be prejudicial to the proper application of steel propeller castings in service, are to be removed by grinding, etc., and the contour of the ground depressions are to be as smooth as possible. Adequate non-destructive inspection is to be carried out on the repaired areas to ensure that all defects have been completely removed to the Surveyor s satisfaction.

2. Weld repairs for the parts where defects were removed are to comply with the following requirements according to the zones for the non-destructive inspection shown in Fig. 7.1:

(1) The zones where weld repairs are allowed are to be as follows:

Zone A: Weld repairs are not allowed.

Zone B: Weld repairs are subject to the approval.

Zone C: Weld repairs are allowed.

(2) Prior to the weld repair on zone B or C mentioned in **(1)** above, a repair plan including welding procedures, welding consumables, edge preparations for weld repair after removing defects and heat treatment is to be submitted and approved by the Society.

(3) An adequate non-destructive inspection is to be carried out on the welded areas to ensure that no defect exists.

3. The welding procedures are to be as deemed appropriate by the Society.

5.7.11 Marking

Marking for steel propeller castings is to comply with the requirements specified in **5.1.12.**

Chapter 6 STEEL FORGING

6.1 Steel Forgings

6.1.1 Application

1. The requirements of 6.1 are to apply to the steel forgings intended to be used for the components of hull construction, equipment, and machinery specified in each part (hereinafter referred to as the steel forgings in 6.1). (steel forgings defined in 6.2, 6.3 and 6.4 are excluded)

2. Steel forgings having characteristics differing from those specified in 6.1 are to comply with the requirements in 1.1.1-2.

6.1.2 Manufacturing Process

1. Steel forgings are to be manufactured from killed steel.

2. Adequate top and bottom discards are to be made to ensure freedom from piping and harmful segregation in the finished forgings.

3. Primary materials such as ingot supplied to other works are to be manufactured at the works approved by the Society with regard to the manufacturing process of the materials.

4. Steel forgings are to be hot worked by means specified in Table 6.1 from ingots, blooms forged or rolled from ingots or blooms made from ingots by a combination of rolling and forging.

5. Steel forgings are to be gradually and uniformly hot worked as far as practicable and are to be brought as nearly as possible to the finished shape and size so as to cause metal flow in the most favourable direction having regard to the mode of stressing in service.

6. Steel forgings are to be subjected to hot work to give enough forging ratio and not less than those given in Table 6.1. The requirements, however, may be suitably modified at the discretion of the Surveyor according to the size or form or the use for which they are intended.

7. Where steel forgings are subjected to surface hardening process such as induction hardening, nitriding or rolling press, data relative to the hardening process is to be submitted for approval to the Society in advance.

8. Steel forgings shaped by flame cutting or scarfing are to have a sufficient machining allowance for removing the heat-affected zone, and the operation is to be carried out before the final heat treatment. Preheating is to be carried out according to the chemical composition, dimensions and form of the steel forgings.

Table 6.1 Forging Ratio

Forging	Hot working	Portion	Forging ratio(1)
Shaft forgings	Forging only	Body	S= 3
		Others	S= 1.5
	Forging and rolling	Body	S=5
		Others	S=3
Ring forgings	Extend hollow forging by forging press ring mill,etc	-	S=3
Disc forgings	Upsetting from ingot(2)	-	U=1/3

Notes:

1 Forging ratio is to be calculated by the following equation:

$S = A/a$, $U = L_1/L$

where:

A : Mean sectional area of original ingot (m^2)

a : Sectional area of the portion after forging (m^2)

L : Length before upsetting (m)

L_1 : Length after upsetting (m)

2 In other cases, upsetting up to $1/2U$ or more is to be carried out to make the value U, as a whole, 1/3.

6.1.3 Kinds

The steel forgings are classified as specified in **Table 6.3**.

6.1.4 Chemical Composition

1. Steel forgings are to have the chemical composition given in **Table 6.2.**

2. Where carbon steel forgings are intended for welded construction, the carbon content is not to exceed 0.23% in consideration of the weldable quality. However, the carbon content may be increased subject to the carbon equivalent (Ceq), which is specified in **1.5.2-2(6),** is to be less than 0.41%.

3. Where low alloy steel forgings are intended for welded construction, the chemical composition is to be obtained an approval by the Society.

For steel forgings complying with the requirements in **-2** or **-3** above, "*W*" is to be suffixed to the markings. (Example: *KSF*45*W*)

4. For steel forgings for rudder stocks and pintles, the chemical composition is to be weldable quality. In case where high strength carbon steel forgings are used, the requirements in **-2** above may be relaxed subject to the approval by the Society. In this case, (*W*) is to be suffixed to the markings.

5. Steel forgings may be added with *Al*, *Nb* or *V* element for greater grain refining of the metal crystal.

6. The manufacturer is to make an analysis of each melt in ladles (Multiple heats are tapped into a common ladle is considered as one heat.) and the results are to be reported to the Survey

Table 6.2 Chemical Composition

Kind	Chemical composition (%) (1)									
	C	*Si*(2)	*Mn*	*P*	*S*	*Cr*	*Mo*	*Ni*	*Cu*	Total residual elements
Carbon steel forging	0.65 max	0.15-0.45	0.30-1.50	0.030 max	0.035 max	0.30(3) max	0.15(3) max	0.40(3) max	0.30(3) max	0.85 max
Low alloy steel forging(4)	0.45 max	0.15-0.45	0.30-1.00	0.030 max	0.030 max	0.40-3.50(4)	0.15-0.70(4)	0.40-3.50(4)	0.30(3) max	-

Notes:

1 Where other elements are added approved by the Society, the contents are to described on the test results.

2 Where the special deoxidation practice is applied, the value of Si may be reduced approved by the Society.

3 Elements are considered as residual elements. Residual elements are not to be intentionally added to the steel.

4 One or more of the elements is to comply with the minimum content.

6.1.5 Heat Treatment

1. Steel forgings are to be annealed, normalized and tempered, or quenched and tempered at a proper stage of manufacturing process for the purpose of grain refining of the metal crystal, removal of residual stress and of obtaining necessary mechanical properties. The normalizing temperature of steel forgings is not to be less than 550°C.

However, where forgings for gearing are not intended for surface hardening, lower tempering temperature may be allowed.

2. Steel forgings which are subjected to any hot work likely to cause change in the crystal structure of metal or to generate residual stress after heat treatment are to be heat treated again.

3. Steel forgings which are locally reheated or subjected to cold work involving an excessive degree of straightening are to be stress relieved accordingly.

4. Where steel forgings are subjected to surface hardening process such as carburizing, heat treatment suitable for surface hardening is to be carried out at a proper stage of the manufacturing process.

5. The furnace intended to be used for heat treatment is to have sufficient size for uniformly heating the steel forgings to the required temperature. The furnace is to be equipped with a device capable of regulating and recording the furnace temperature.

6. Sufficient thermocouples are to be connected to the furnace charge to measure and record that its temperature is adequately uniform unless the temperature uniformity of the furnace is verified at regular intervals.

7. The forge is to maintain records of heat treatment identifying the furnace used, furnace charge, date, temperature and time at temperature

6.1.6 Mechanical Properties

1. The mechanical properties of steel forgings are to conform to the requirements given **Table 6.3.** However, the mechanical properties of low alloy steel forgings which are applied following may be deemed appropriate by the Society.

(1) Where the value of yield point or proof stress of the forgings is deferred to the value of **Table 6.3**.

(2) Where the forgings are used for rudder stoke or pintles etc.

2. Intermediate values of those tabulated in **Table 6.3** may be applicable where approval of the Society is obtained. In this case, the values are to be obtained by interpolation and counting fractions over 0.5 as one and disregarding the rest.

3. The difference in tensile strength between the maximum and minimum values in case where two or more tension test specimens were taken from one steel forgings is not to exceed $70 N/mm^2$ for steel forgings less than $600 N/mm^2$ in the specified tensile strength and not to exceed $100 N/mm^2$ for steel forgings not less than $600 N/mm^2$ in the specified tensile strength.

4. Where batch material tests are carried out, the Surveyor may request hardness test on each product material. In this case, the difference in measured hardness between the maximum and minimum values of the steel forgings of the same lot is not to exceed 20 (H_B) for steel forgings less than $600 N/mm^2$ in the specified tensile strength and is not to exceed 30 (H_B) for steel forgings not less than $600 N/mm^2$ in the specified tensile strength.

5. Gears and rims are to conform to the requirements in **6.1.15-4** for hardness test

Table 6.3 Mechanical Properties of Steel Forgings

Kind	Grade	Tensile strength ($N/mm2$)	Yield point or proof stress ($N/mm2$)	Elongation $(L = 5.65\sqrt{A})$ (%)		Reduction of area (%)	
				L	*T*	*L*	*T*
Carbon steel forging	KSF41	400-520	200 min	26 min	19 min	50 min	35 min
	KSF45	440-560	220 min	24 min	18 min	50 min	35 min
	KSF50	490-610	245 min	22 min	16 min	45 min	30 min
	KSF55	540-660	270 min	21 min	15 min	43 min	29 min
	KSF60	590-710	295 min	19 min	13 min	40 min	27 min
	KSF65	640-790	320 min	17 min	12 min	40 min	27 min
	KSF70	690-840	345 min	16 min	12 min	35 min	24 min
	KSF75	740-890	370 min	15 min	11 min	35 min	24 min
	KSF78	760-910	380 min	14 min	10 min	35 min	24 min
Low alloy steel forgings	KSFA60	590-740	355 min	18 min	14 min	50 min	35 min
	KSFA65	640-790	385 min	17 min	13 min	50 min	35 min
	KSFA70	690-840	415 min	16 min	12 min	46 min	31 min
	KSFA75	740-890	445 min	15 min	11 min	45 min	30 min
	KSFA80	780-930	470 min	14 min	10 min	42 min	28 min
	KSFA85	830-980	525 min	13 min	9 min	40 min	27 min
	KSFA90	880-1030	600 min	13 min	9 min	40 min	27 min
	KSFA95	930-1130	650 min	12 min	8 min	36 min	25 min
	KSFA100	980-1180	685 min	12 min	8 min	35 min	24 min
	KSFA105	1030-1230	720 min	11 min	7 min	35 min	24 min
	KSFA110	1080-1280	755 min	11 min	7 min	35 min	24 min

Notes:

1 Letters "*L*" and "*T*" in the Table signify the direction of the specimen taken from longitudinal and tangential to the product respectively.

2 The requirement for carbon steel forgings in above Table are applicable to those annealed, normalized, normalized and tempered or quench and tempered.

3 The requirement for low alloy steel forgings is applicable to those quenched and tempered. Where they are normalized and tempered, the mechanical properties are to be approved by the Society.

6.1.7 Mechanical Test

1. Mechanical tests for steel forgings are to be carried out in accordance with the requirements given in Chapter 2.

2. Where the tensile test or hardness test fails to meet the requirements, retest may be carried out in accordance with the requirements of 1.4.4.

3. For propeller shafts used for the ships with ice class notation, Charpy V-notch impact testing is to be carried out for all steel types at -10°C and the average energy value is to be minimum 27 *J* (using a set of three *U*4 test specimen for longitudinal test). Where energy value of two or more specimens among a set of specimens are less than 27 *J* or where one individual value is less than 70*%* of 27 *J*, the test is considered to have failed. Additional tests may be carried out in accordance with the requirements specified in 3.1.10-3.

6.1.8 Selection of Test Specimens

1. Unless otherwise specially specified, the test specimens for steel forgings are, after final heat treatment, to be taken longitudinal from a part having a sectional area not less than that of the body of forging. But they are to be taken tangential where deemed necessary according to the form of the forgings.

2. The test specimens are not to be separated from the body before the final heat treatment has been completed. In the case of stamp forging or other case of forging requiring the surface hardening process, the test specimens may be separated at a proper stage before the final heat treatment providing that such is approved by the Surveyor.

3. Unless otherwise agreed, the longitudinal axis of test specimens is to be positioned as follows:

(1) For thickness or diameter up to maximum 50*mm*, the axis is to be at the mid-thickness or the centre of the cross section.

(2) For thickness or diameter greater than 50*mm*, the axis is to be at one quarter thickness (mid-radius) or 80*mm*, whichever is less, below any heat treated surface.

4. Number of test specimens is to be as given in **(1)** through **(4)** of the following requirement. In this case, one set of specimens means one tensile test specimen. However, "One set of specimens" means one tensile test specimen and one set of three impact test specimens for propeller shafts used for the ships with ice class notation:

(1) Where a steel forging is 4 *tons* and over in mass as heat treated (hereinafter referred to as mass), one set of test specimens is to be taken from both ends of the steel forging.

(2) Where a steel forging is 500*kg* up to 4 *tons* (exclusive) in mass, one set of test specimens is to be taken from one end of the forging.

(3) Where a number of steel forgings of similar form and size, each of which is 250*kg* up to 500*kg* (exclusive) in mass, are made from the same ingot (or bloom) and heat treated simultaneously, one set of test specimens is to be taken from each three forgings or a fraction thereof.

(4) Where a number of steel forgings of similar form and size, each of which is less than 250*kg* in mass, are made from same ingot (or bloom) and heat treated simultaneously in the same furnace, one set of test specimens is to be taken from a total mass not exceeding 6 tons in case that the forgings are annealed,

normalized, normalized and tempered and is to be taken from a total mass not exceeding 3 tons in case that the forgings are quench and tempered. Where approved by the Society, test specimens may be taken from the test samples which forged from same ingot and same condition, and heat treated by same furnace on same time.

5. The steel forgings heat treated with continuous heat treatment furnace, without changing the heat treatment conditions are to be considered that they have been simultaneously heat treated.

6.1.9 Surface Inspection and Dimension Inspection

1. When heat treatment and final machining are completed and, if necessary, at a proper stage during machining, surface inspection is to be carried out.

2. Dimension inspection of the steel forgings is to be conducted under the responsibility of the manufacturer.

6.1.10 Non-Destructive Testing

1. Steel forgings are to be subjected to non-destructive testing in accordance with **(1)** and **(2)** of the following requirements:

(1) Ultrasonic test

(a) The following steel forgings are to be subjected to ultrasonic test at an appropriate stage of the manufacturing process and the test reports are to be showed or submitted to the Surveyor.

i. Rudder stocks and pintles

ii. Steel forgings which are to be subjected to ultrasonic test according to the requirement specified in **2.2.1-1, Part 7**

iii. Thrust shafts, intermediate shafts and propeller shafts

iv. Reduction gears and reduction gear shafts

v. Turbine rotors, turbine discs and turbine blades

(b) Performances of ultrasonic testing apparatus are to be of good efficiency for testing of these forgings.

(c) Operator engaged in the ultrasonic test is to have sufficient technique and experience for the testing of the forgings.

(2) Magnetic particle or liquid penetrant testing

The important parts of the following steel forgings are to be subjected to magnetic particle or liquid penetrant test at an appropriate stage of the manufacturing process:

(a) Steel forgings which are to be subjected to magnetic particle test or liquid penetrant test according to the requirement specified in **2.2.1-1, Part 7**.

(b) Propeller shafts.

(c) Reduction gears.

(d) Turbine rotors, turbine discs and turbine blades.

2. The Society may require sulphur print test for the portion of gears where teeth will be cut.

3. In place of the test methods given in, **-1** and **-2**, the Society may accept the application of other non-destructive tests considered adequate by the Society.

4. The Society may require non-destructive test for the steel forgings other than those specified in **-1** when such is deemed necessary by the Society.

5. The welded parts of steel forgings used for welded construction are to be subjected to the non-destructive tests considered adequate by the Society.

6.1.11 Repair of Defects

1. In the event of finding defects considered harmful for the intended use in the steel forgings, the defects are to be removed by grinder, etc.

2. After removing the defects, magnetic particle test or liquid penetrant test is to be carried out to ensure that all defects have been removed completely.

3. The steel forgings from which defects are removed are to be approved by the Surveyor. The resulting grooves are to have a bottom radius of approximately three times the groove depth and are to be blended into the surrounding surface so as to avoid any sharp contours and stress concentration.

4. Repair welding of forgings except crankshaft forgings may be permitted subject to approval of the Society. In such cases, full details of the extent and location of the repair, the proposed welding procedure, heat treatment and subsequent inspection procedures are to be submitted for the approval.

5. The forging manufacturer is to present records of repairs and subsequent inspections traceable to each forging repaired, to the surveyor on request.

6.1.12 Marking

Steel forgings which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **1.5.1**. For steel forgings to which the requirements given in **6.1.6-2** have been applied, the value corresponding to the required tensile strength employed is to be used to the grade mark. (*ex*. Where the required tensile strength employed is 460N/mm^2, "*KSF*47" is to be indicated)

6.1.13 Additional Requirements for Crankshafts

1. Where solid crank shafts of 250*mm* and over in finished diameter are manufactured by free forging, the heat treatment is normally to be carried out after crank parts are machined as nearly as possible to the finished shape. In this case, one set of test specimens is to be taken from each end of the shaft.

2. For solid crankshafts manufactured adopting the special forging processes, semi-built-up crank throws and full-built-up crank webs, the preliminary tests instructed by the Society are to be carried out, in connection with the manufacturing processes and the selection of test specimens.

3. Where the special forging processes are adopted to reduce the size of crank shaft according to the requirements in **2.3.1-1, Part 7**, the preliminary tests instructed by the Society are to be carried out.

6.1.14 Additional Requirements for Turbine Rotors

1. The test specimens for turbine rotors are to be taken in accordance with **(1)** and **(2)** of the following requirements:

(1) Where the turbine rotor is greater than 3 *tons* in mass, one set of longitudinal test specimens is to be taken from each end of the shaft portion and one set of tangential test specimens in the tangential direction from the body portion respectively. (*See* **Fig. 6.1**)

(2) Where the turbine rotor is not exceeding 3 *tons* in mass, one set of longitudinal test specimens is to be taken from one end of the shaft portion and one set of tangential test specimens in the tangential direction from the body portion respectively.

2. For each turbine disc, one set of tangential test specimens in the tangential direction is to be taken from the boss portion. (*See* **Fig. 6.2**)

3. Solid forged turbine rotors intended for main propulsion service where the inlet steam temperature exceeds 400°C are to be subjected to stability tests at least once at a suitable time after rough machining or heat treatment.

This requirement is also applicable to rotors fabricated by welding. The method of stability test is to be approved by the Society prior to the test.

6.1.15 Additional Requirements for Reduction Gears

1. Pinions intended for reduction gears are to conform to items **(1)** through **(4)** of the following requirements:

(1) Where the finished diameter over the portion where teeth will be cut is not exceeding 200*mm*, one set of longitudinal test specimens is to be taken from one end of the journal. (*See* **Fig. 6.3**)

(2)

(a) Where the above finished diameter is greater than 200*mm* and the mass of one piece is greater than 3 *tons*, one set of tangential test specimens is to be taken from each end of the adjacent portion where the teeth will be cut (*see* **(A)** in **Fig. 6.4**). In the case of pinions where the diameter of journal precludes the preparation of test specimens from this portion, above tangential test specimens may be taken from the ends of the journal (*see* **(B)** in **Fig. 6.4**)). Where the finished journal diameter is not exceeding 200 *mm*, one set of longitudinal test specimens may be taken from each end of the journals (*see* **(C)** in **Fig. 6.4**)).

(b) Where the finished diameter is greater than 200*mm* and the mass is not exceeding 3 *tons*, one set of test specimens is to be taken from one end of the pinion in accordance with **(a)**.

(3) Where the pinions are so designed that the tooth body is inserted in the shaft, one set of tangential test specimens in the tangential direction is to be taken from the ends of the tooth body.

(4) Where a number of pinions, each of which mass less than 250*kg*, are made from the same ingot and heat treated simultaneously, one set of test specimens is to be taken from every two pinions at least.

2. Rims intended for reduction gears and cam shaft driving gears of diesel engine (*see* **2.2.1-1, Part 7**) are to conform to items **(1)** through **(3)** of the following requirements:

(1) Where the finished diameter of a rim exceeds 2.5 *meters* or the mass exceeds 3 *tons*, one set of tangential test specimens is to be taken from each end of the rim at the positions diametrically opposed (*see* **Fig. 6.5**). In case where the finished width of the rim is not exceeding 1*m*, one set each test specimens may be taken from either one end of the rim at the positions diametrically opposed. The mechanical properties are to conform to the requirements applicable to the case of test specimens taken is the direction parallel to the forging direction.

(2) Where the mass and finished diameter are different from those given in **(1)** above, one set of test specimens may be taken from one end of the rim.

(3) Where a number of separate forgings, each of which is not exceeding 250*kg* in mass, are made from the same ingot (or bloom) and heat treated simultaneously, one set of test specimens is to be taken from every two rims at least, in accordance with **(2)** above.

3. Where gears are to be subjected to the surface hardening, the detailed information relating to manufacturing is to be submitted and the test procedure is to be approved by the Society before the work is commenced. In this case, a preliminary test is to be carried out where deemed necessary by the Society.

4. The gears specified in **-1** to **-3** are to be subjected to the following hardness tests:

(1) Non-surface-hardened gears

Four hardness tests are to be made at equal distances round the circumference prior to machining the gear teeth.

Where the width of the toothed portion exceeds 500*mm*, hardness tests are to be made at each end of the toothed portion.

(2) Surface-hardened gears

Hardness tests are to be made on the surface of gear teeth when surface hardening has been completed.

(3) The measured hardness value is to be approved by the Society.

Fig. 6.1 Selection of Test Specimens for Turbine Rotor

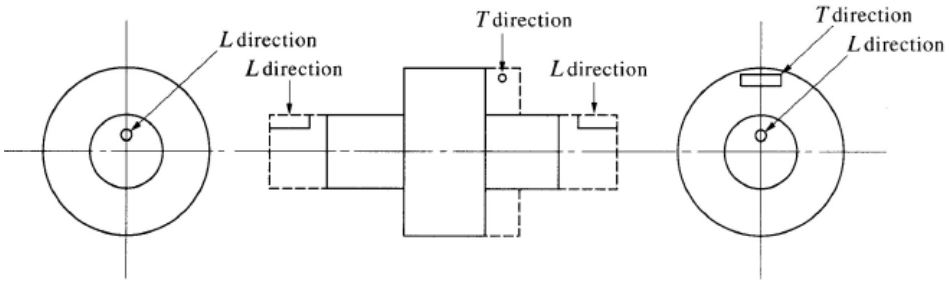
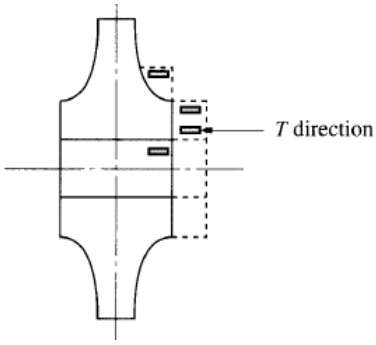


Fig. 6.2 Selection of Test Specimens for Turbine Disc



Note: One set of test specimens may be taken from one location given in the figure.

Fig. 6.3 Selection of Test Specimens for Pinion Not Exceeding 200 *mm* in Finished Diameter

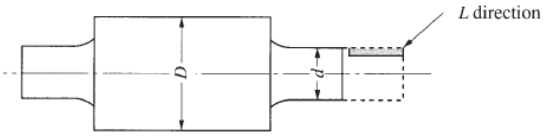


Fig. 6.4 Selection of Test Specimens for Pinion Greater Than 200 *mm* in Finished Diameter

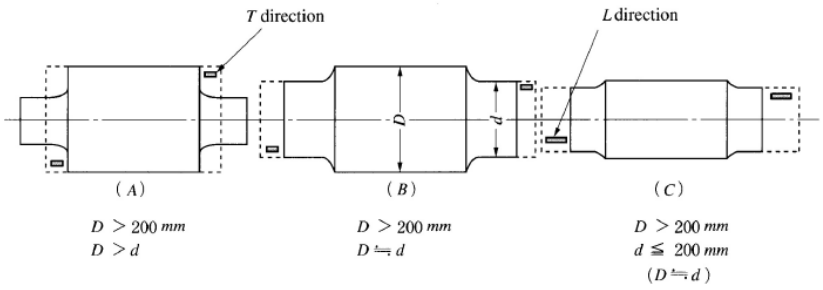
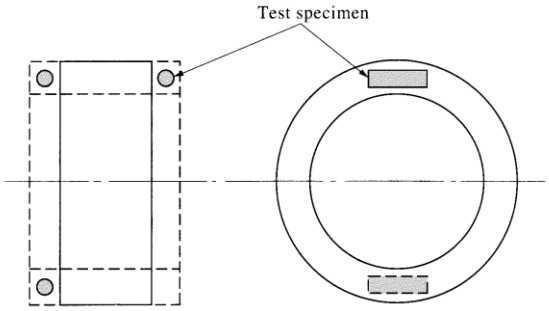


Fig. 6.5 Selection of Test Specimens for Rim



6.2 Stainless Steel Forgings

6.2.1 Application

1. The requirements are to apply to the stainless steel forgings for propeller shafts and valves and pipe fittings in piping systems used at low temperature service (-165°C and over in design temperature) or corrosion-resisting service (hereinafter referred to as stainless steel forgings in 6.2).

2. Stainless steel forgings having characteristics differing from those specified in 6.2 are to comply with the requirements in 1.1.1-2.

3. In addition to the requirements given in 6.2 general requirements may be considered by the Society.

6.2.2 Manufacturing Process

Manufacturing process of stainless steel forgings is to be as 6.1.2.

6.2.3 Kinds

The steel forgings are classified into 9 grades as specified in Table 6.4.

6.2.4 Chemical Composition

Stainless steel forgings are to have the chemical composition given in Table 6.4.

6.2.5 Heat Treatment

1. The stainless steel forgings are generally to receive a solid solution treatment.

2. Stainless steel forgings which are subjected to any hot work likely to cause change in the crystal structure of metal or to generate residual stress after heat treatment are to be heat treated again.

3. Stainless steel forgings which are subjected to any cold work involving an excessive degree of straightening are to be stress relieved accordingly.

4. The furnace intended to be used for heat treatment is to have sufficient size for uniformly heating the stainless steel forgings to the required temperature. The furnace is to be equipped with a device capable of regulating and recording the furnace temperature.

6.2.6 Mechanical Properties

1. The mechanical properties of stainless steel forgings are to conform to the requirements given in **Table 6.5**.

For the application of the Table, the stainless steel forgings are receive a solid solution treatment.

2. Notwithstanding in **-1**, for stainless steel forgings for valves and pipe fittings in piping systems used at low temperature, hardness tests may be omitted.

3. Where deemed necessary by the Society, other tests on notch toughness or corrosion-resistance may be required in addition to the specified test.

Table 6.4 Grades and Chemical Composition

Grade	Chemical composition (%)							
	C	*Mn*	*P*	*S*	*Si*	*Cr*	*Ni*	*Others*
KSUSF304	0.08 max	2.00 max	0.040 max	0.030 max	1.00 max	18.00-20.00	8.00-12.00	-
KSUSF304L	0.030 max					18.00-20.00	8.00-12.00	
KSUSF309S	0.08 max					22.00-24.00	12.00-15.00	
KSUSF310S	0.08 max					24.00-26.00	19.00-22.00	
KSUSF316	0.08 max					16.00-18.00	10.00-14.00	*Mo* 2.00-3.00
KSUSF316L	0.030 max					16.00-18.00	10.00-14.00	*Mo* 2.00-3.00
KSUSF317	0.08 max					18.00-20.00	10.00-15.00	*Mo* 3.00-4.00
KSUSF321	0.08 max					17.00-19.00	9.00-12.00	$Ti \geq 5 \times C$
KSUSF347	0.08 max					17.00-19.00	9.00-13.00	$Nb+Ta \geq 10xC$

Table 6.5 Mechanical Properties

Grade	Tensile test				Hardness test		
	Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) ($L = 5.65\sqrt{A}$)	Reduction of area (%)	HB	HRB	HV
*KUSUF*304*L* *KUSUF*316*L*	175 min	450 min	37 min	50 min	187 max	90 max	200 max
Others	205 min	520 min	37 min	50 min			

6.2.7 Mechanical Tests

1. Mechanical tests for stainless steel forgings are to be carried out in accordance with the requirements given in **Chapter 2**.

2. Where the tensile test or hardness test fails to meet the requirements, retest may be carried out in accordance with the requirements of **1.4.4**.

3. The difference in tensile strength between the maximum and minimum values in case where two or more tensile test specimens were taken from one stainless steel forgings is not to exceed 70N/mm^2.

4. The difference in measured hardness between the maximum and minimum values of the stainless steel forgings of the same lot is not to exceed 20 (H_B).

6.2.8 Selection of Test Specimens

1. The number of tension test specimens is to comply with the requirements given in **6.1.8**.

2. The tensile test specimens are to be cut with their longitudinal axes parallel to the direction of forging, unless otherwise specially provided.

3. Where tests are carried out in accordance with **6.1.8-3(3)** or **(4)**, the Surveyor may require a hardness test for each steel forging.

4. Tensile test specimen is to comply with the requirements given in **Table 2.1**.

6.2.9 Surface Inspection and Dimension Inspection

1. When heat treatment and final machining are completed and, if necessary, at a proper stage during machining, surface inspection is to be carried out.

2. Dimension inspection of the stainless steel forgings is to be conducted under the responsibility of the manufacture.

6.2.10 Non-destructive Testing

1. Stainless steel forgings used for propeller shafts and so on are to be subjected to non-destructive testing in accordance with **(1)** and **(2)** of the following requirements:

(1) Ultrasonic test

(a) The stainless steel forgings are to be subjected to ultrasonic test at an appropriate stage of the manufacturing process and the test reports are to be shown or submitted to the Surveyor.

(b) Performances of ultrasonic testing apparatus are to be of good efficiency for testing of these forgings.

(c) Operator engaged in the ultrasonic test is to have sufficient technique and experience for the testing of the stainless steel forgings.

(2) The important parts of the stainless steel forgings are to be subjected to liquid penetrant test at an appropriate stage of the manufacturing process.

2. In place of the test methods given in, **-1**, the Society may accept the application of other non-destructive test considered adequate by the Society.

6.2.11 Repair of Defects

The repair of defects of the stainless steel forgings are to be in accordance with the requirements given in 6.1.11.

6.2.12 Marking

The markings of the stainless steel forgings are to be in accordance with the requirements given in 1.5.1.

6.3 Steel Forgings for Chains

6.3.1 Application

1. The requirements are to apply to the steel forgings intended to be used for chain accessories such as shackle, swivel, etc. of chains specified in Part 5 (hereinafter referred to as "steel forgings" in 6.3).

2. Steel forgings having characteristics differing from those specified in 6.3 are to comply with the requirements in 1.1.1-2.

3. In addition to the requirements given in 6.3, general requirements may be considered by the Society.

6.3.2 Kinds

The steel forgings are classified into 5 grades as specified in Table 6.6.

Table 6.6 Grades of Steel Forgings

Grade		Application
Steel forging for Grade 2 chain	*KSFC*50	Grade 2 chain
Steel forging for Grade 3 chain	*KSFC*70	Grade 3 chain
Grade R3 steel forgings	*KSFCR*3	Grade R3 chain
Grade R3S steel forgings	*KSFCR*3*S*	Grade R3S chain
Grade R4 steel forgings	*KSFCR*4	Grade R4 chain
Grade R4S steel forgings	*KSFCR*4*S*	Grade R4S chain
Grade R5 steel forgings	*KSFCR*5	Grade R5 chain

6.3.3 Heat Treatment

The steel forgings are to be normalized, normalized and tempered, quenched and tempered or heat treated by the process approved by the Society.

6.3.4 Deoxidation Practice and Chemical Composition

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in **Table 6.7**. Elements other than specified in **Table 6.7** may be added subject to a special approval by the Society.

6.3.5 Mechanical Properties

The mechanical properties of each grade are to comply with the requirements specified in **Table 6.8**.

Table 6.7 Deoxidation Practice and Chemical Composition (%)

Grade	Deoxidation	*C*	*Si*	*Mn*	*P*	*S*	*Al*[(1)]
*KSFC*50	Fine grained Killed	0.24 max	0.15-0.55	1.60max	0.035max	0.035max	0.020min
*KSFC*70		0.36 max	0.15-0.55	1.00-1.90	0.035max	0.035max	0.020min
*KSFCR*3		Detailed chemical composition is to be approved by the Society .For Grade *KSFCR*4, *KSFCR*4*S* and *KSFCR*5, the steel should contain a minimum of 0.2 % molybdenum.					
*KSFCR*3*S*							
*KSFCR*4							
*KSFCR*4*S*							
*KSFCR*5							

Note:

1 Al content is to be represented by the total Al content and may be replaced partly by other fine graining elements.

Table 6.8 Mechanical Properties

Grade	Tensile test				Impact test(1)	
	Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) (L=5 d) (N/mm^2)	Reduction of area (%)	Testing temperature (°C)	Minimum mean absorbed energy (J)
*KSFC*50	295 min	490-690	22 min	-	0	27
*KSFC*70	410 min	690 min	17 min	40 min	0	60
*KSFCR*3	410 min	690 min	17 min	50 min	-20(3)	40(3)
*KSFCR*3*S*	490 min	770 min	15 min	50 min	-20(3)	45(3)
*KSFCR*4	580 min	860 min	12 min	50 min	-20	50
*KSFCR*4*S*	700 min	960 min	12 min	50 min	-20	56
*KSFCR*5	760 min	1000 min	12 min	50 min	-20	58

Notes:

1 When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified minimum mean absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified minimum mean absorbed energy, the test is considered to have failed.

2 Aim value of yield to tensile ratio for grades *KSFCR*3, *KSFCR*3*S, KSFCR*4, *KSFCR*4*S* and *KSFCR*5 is to be maximum 0.92.

3. Impact test of grade *KSFCR*3 and *KSFCR*3*S* may be carried out at the temperature 0°C where approved by the Society. In this case, minimum mean absorbed energy is to be not less than 60*J* for grade *KSFCR*3 and 65*J* for grade *KSFCR*3*S*.

6.3.6 Selection of Test Specimens

1. One sample steel forging is to be selected from every number of steel forgings for Grade 2 and 3 steel forgings specified in **Table 6.9** or a fraction thereof and for Grade *R*3, *R*3*S* and *R*4 steel forgings specified in **Table 6.10** or a fraction thereof, which belong to the same heat, according to the nominal diameter of the common links to which the steel forgings are intended to link. Where specially approved by the Society, the test sample may be taken from representative part of the steel forgings at a proper time during manufacturing, or separate sample forged to the forge ratio equivalent to that of the steel forgings. In this case, the test sample is to be heat-treated simultaneously with the steel forgings.

2. The test specimens from one test sample prepared according to **-1** are to be cut with their longitudinal axis parallel to the direction of steel forging and to consist of one tensile test specimen at one set (3 pieces) of impact test specimens.

3. The tensile and impact test specimens are to be taken from the test sample in the longitudinal direction at a depth of 1/6 diameter from the surface or as close as possible to this position (*See* **Fig. 3.2**).

4. Tensile and impact test specimens are to comply with the requirements specified in **Table 2.1** and **Table 2.5** respectively.

Table 6.9 Number of Steel Forgings for Selection of One Sample of Grade 2 and 3 Chain

Normal diameter *d* (*mm*) of common links to which steel forging are linked	Number of steel forgings belonging to the same heat
$12.5 \leq d \leq 28$	250
$30 \leq d \leq 48$	100
$50 \leq d \leq 68$	75
$70 \leq d \leq 98$	50
$100 \leq d \leq 162$	25

Table 6.10 Number of Steel Forgings for Selection of One Sample of Grade *R*3, *R*3S, *R*4, *R*4S and *R*5 Chain

Normal diameter *d* (*mm*) of common links to which steel forging are linked	Number of steel forgings belonging to the same heat
$50 \leq d \leq 75$	75
$75 \leq d \leq 100$	50
$100 \leq d \leq 125$	25
$125 \leq d \leq 150$	20
$150 \leq d$	15

6.3.7 Surface Inspection

Surface inspection for all grades is to be carried out and it is to be confirmed that there is no harmful defect.

6.3.8 Non-Destructive Test

For grades *KSFCR*3, *KSFCR*3*S KSFCR*4, *KSFCR*4S and *KSFCR*5 all steel forgings are subjected to ultrasonic examination at an appropriate stage of the manufacture and it is to be confirmed that there is no harmful defect.

6.3.9 Additional Tests before Rejection

Where the tensile test or impact test on the selected first test specimens fails to meet the requirements, additional tests may be carried out according to the requirements given in **3.6.9**.

6.3.10 Marking

Steel forgings which have proved satisfactory compliance with the required tests are to be marked with identification marks in accordance with the requirements in 1.5.1.

6.4 Steel Forgings for Low Temperature Service

6.4.1 Application

1. The requirements are to apply to the steel forgings for valves and pipe fittings in piping systems intended to be used for low temperature service (hereinafter referred to as "steel forgings").

2. Steel forgings other than specified in 6.4 or those used in other parts than specified in **-1** are to comply with the requirements given 1.1.1-2.

3. In addition to the requirements given in 6.4, general requirements may be considered by the Society.

6.4.2 Kinds

The steel forgings are classified into 5 grades as given in Table 6.11.

6.4.3 Heat Treatment

The steel forgings are to be normalized and tempered, quenched and tempered or double-normalized and tempered.

6.4.4 Deoxidation Practice and Chemical Composition

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in Table 6.11.

Table 6.11 Grades and Chemical Composition (%)

Grade	Deoxidation	*C*	*Si*	*Mn*	*P*	*S*	*Ni*	*Cr*	*Cu*	*Al*
KLFA	Fully Killed fine grain	0.23 max	0.15-0.35	1.10 max	0.030 max	0.030 max	-	-	-	-
KLFB		0.20 max	0.15-0.35	1.60 max			-	-	-	-
KLFC		0.12 max	0.10-0.35	0.55-1.00			0.50-0.95	0.50-0.95	0.40-0.75	0.04-0.30
*KLF*3		0.20 max	0.15-0.35	0.90 max			3.25-3.75	-	-	-
*KLF*9		0.10 max	0.10-0.35	0.90 max			8.50-9.60	-	-	-

6.4.5 Mechanical Properties

The mechanical properties of steel forgings are to comply with the requirements given in **Table 6.12**.

Where deemed necessary by the Society, other tests may be required in addition to the tests specified in **-1**.

6.4.6 Selection of Test Specimens

1. The number of test specimens is to be in accordance with the requirements specified in **6.1.8**.

2. The test specimens for tensile and impact tests are to be cut with their longitudinal axes parallel to the direction of forging, except where otherwise specially specified.

3. Where tests are made in accordance with the requirements in **6.1.8-3(3)** and **(4)**, the Surveyor may require a hardness test for each forging.

4. The size and dimensions of tensile and impact test specimens are to comply with the requirements specified in **Table 2.1** and **Table 2.5** respectively.

6.4.7 Additional Tests before Rejection

1. Where the tensile tests from the first test specimens selected fail to meet the requirements, additional tests may be carried out according to the requirements given in **1.4.4**.

2. Regarding the impact tests, additional tests are to be carried out according to the requirements given in **3.1.10-3**.

6.4.8 Marking

Marking of the steel castings is to comply with the requirements given in **6.1.12** and in case the requirement in **Note (1)** of **Table 6.12** has been applied, "*T*" is to be suffixed to the making.

(Example: *KLFA*-25*T*)

Table 6.12 Mechanical Properties

	Tensile test				Impact test(2)	
Grade	Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation ($L = 5.65\sqrt{A}$) (N/mm^2)	Reduction of area (%)	Testing temperature (°C)	Mean absorbed energy (J)
KLFA	205 min	410 min	23 min	40 min	-40 (1)	27 min
KLFB	275 min	490 min	20 min		-50(1)	
KLFC	205 min	410 min	23 min		-60(1)	
*KLF*3	275 min	490 min	23 min	50 min	-95	34 min
*KLF*9	520 min	680 min	19 min	45 min	-196	41 min

Notes:

1 Impact test temperature for steel forgings specified in *IGC Code IMO* is to be 5°C below the design temperature or 20°C, whichever is the lower.

2 Where the absorbed energy of more than one of a set of test specimens is under the required minimum mean absorbed energy, or where the absorbed energy of one test specimen is under 70% of the required value, the test is considered to be failed.

Chapter 7 COPPER AND COPPER ALLOYS

7.1 Copper and Copper Alloy Pipes and Tubes

7.1.1 Application

1. The requirements are to apply to the copper and copper alloy pipes and tubes.

2. Copper and copper alloy pipes and tubes are to conform to the requirements in *recognized national or international standards*. However, the manufacturing approval test by the Society is not required.

3. Copper and copper alloy pipes and tubes having characteristics differing from those specified in 7.1 are to comply with the requirements in 1.1.1-2.

7.1.2 Kinds

Copper and copper alloy pipes and tubes are classified as specified in Table 7.1.

7.1.3 Mechanical Properties

The mechanical properties of copper and copper alloy pipes and tubes are to comply with the requirements given in Table 7.2.

Table 7.1 Kind and Grade

Kind		Grade
Copper seamless pipes and tubes	Phosphorus deoxidized copper	*C*1201,*C*1220
Copper alloy seamless pipes and tubes	Brass	*C*2600,*C*2700, *C*2800
	Brass for condenser tube	**C**4430,*C*6870,*C*6871,*C*6872
	Cupro-nickel for condenser	*C*7060,*C*7100,*C*7150

Table 7.2 Mechanical Properties

Kind	Grade	Tensile test	
		Tensile strength (N/mm^2)	Elongation (%)
Phosphorus deoxidized copper seamless pipes and tubes	*C*1201 *C* 1220	205 min	40 min
Brass seamless pipes and tubes	*C* 2600	275 min	45 min
	C 2700	295 min	40 min
	C 2800	315 min	35 min
Brass seamless pipes and tubes for condenser	*C* 4430	315 min	30min
	C 6870 *C* 6871 *C* 6872	370 (1)min	40 min
		350 (2)min	40 min
Cupro-nickel seamless pipes and tubes for condenser	*C* 7060	275 min	30 min
	C 7100	315 min	30 min
	C 7150	360 min	30min

Notes:

1 It is applicable to those having 5 *mm* and up to 50 *mm* in outside diameter.

2 It is applicable to those having over 50 *mm* up to 200 *mm* in outside diameter.

7.1.4 Testing and Inspection

Testing and inspection of pipes and tubes are to comply with the requirements specified in *recognized national or international standards*. Those subjected to the maximum working pressure not exceeding 1 *MPa* may not require the presence of the Society's Surveyor.

7.2 Copper Alloy Castings

7.2.1 Application

1. The requirements specified in 7.2 are to apply to the copper alloy casting to be used for propellers and propeller blades (hereinafter referred to as "propeller castings" in 7.2).

2. Propeller castings having characteristics differing from those specified in 7.2are to comply with the requirements in **1.1.1-2.**

3. Copper alloy castings to be used for important parts other than propeller castings are to conform to the requirements given in *recognized national or international standards*. In this case, testing and inspection may not require the presence of the Society s Surveyor except where special requirements are given in connection with the design.

7.2.2 Kinds

The propeller castings are classified as specified in **Table 7.3.**

Table 7.3 Kinds and Grades

Kind	Grades
Manganese bronze casting. Grade 1	*KHBsC*1
Ni-Manganese bronze casting. Grade 2	*KHBsC*2
Ni-Aluminium bronze casting. Grade 3	*KA ℓ BC3*
Mn- Aluminium bronze casting. Grade 4	*KA ℓ BC4*

7.2.3 Chemical Composition

The chemical composition of propeller castings is to comply with the requirements specified in **Table 7.4**. Moreover, for *KHBsC*1 and *KHBsC*2, they are also to comply with the following **(1)** or **(2).**

(1) The zinc equivalent as specified below does not exceed 45%.

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

Where

$A = Sn + 5Al - 0.5Mn - 0.1Fe - 2.3Ni$ (%)

(2) Each tensile test specimen is examined metallographically, and the proportion of alpha-phase determined from an average of five counts is not less than 25%.

Table 7.4 Chemical Composition (%)

Grade	*Cu*	*Al*	*Mn*	*Zn*	*Fe*	*Ni*	*Sn*	*Pb*
*KHBsC*1	52-62	0.5-3.0	0.5-4.0	35-40	0.5-2.5	1.0 max	1.5 max	0.5 max
*KHBsC*2	50-57	0.5-2.0	1.0-4.0	33-38	0.5-2.5	2.5-8.0	1.5 max	0.5 max
KA ℓ BC3	77-82	7.0-11.0	0.5-4.0	1.0 max	2.0-6.0	3.0-6.0	0.1 max	0.03 max
KA ℓ BC4	70-80	6.5-9.0	8.0-20.0	6.0 max	2.0-5.0	1.5-3.0	1.0 max	0.05 max

7.2.4 Heat Treatment

Where propeller castings are heat treated, detailed procedure for the heat treatment is to be submitted for approval before the heat treatment is started.

7.2.5 Mechanical Properties

The mechanical properties of propeller castings are to comply with the requirements specified in **Table 7.5**.

Table 7.5 Mechanical Properties

Grade	Proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) (L=5 d)
*KHBsC*1	175 min	440 min	20 min
*KHBsC*2	175 min	440 min	20 min
KA ℓ BC3	245 min	590 min	16 min
KA ℓ BC4	275 min	630 min	18 min

Notes:

1 The requirements specified in this Table apply to specimens cut from separately-cast samples, where specimens cut from propeller casting itself, the requirements are to be deemed appropriate by the Society.

2 The requirements concerning proof stress apply to cases where proof stress is required by the Society in relation with design.

7.2.6 Mechanical Tests

1. Mechanical tests on propeller castings are to be tensile test, and to be carried out in compliance with the requirements specified in **Chapter 2**.

2. Where any test result from the first test specimen selected fails to meet the requirements, additional tests may be conducted according to the requirements given in **1.4.4**. The test specimens for the additional tests are to be taken from the same sample from which the first test specimen is taken or from other test samples representative of the propeller castings.

7.2.7 Selection of Test Specimens

1. The test samples for propeller castings are to be separately cast from the propeller castings.

2. The test samples are to be cast in moulds made of the same material as the mould for the propeller castings and they are to be cast under the same condition as the propeller castings. The shapes and dimensions of the test samples are to be deemed appropriate by the Society.

3. The test samples are to be cast from the same ladle of metal used for the propeller castings except the cases where special requirements are given by the Society. Where more than one ladles of metal are used for propeller castings without mixing before pouring, one test sample is to be provided for each ladle.

4. One test specimen is to be taken from each test sample.

7.2.8 Surface and Dimensional Inspection

1. The propeller castings are to be subjected to visual inspection on zone A, B and C shown in **Fig. 7.1** in the finished condition. The inspection may also be required at other proper processing stages if necessary.

2. The dimensional inspections of propeller castings are to be conducted by the manufacturer. Where straightening of a bent blade is carried out, the procedure for the straightening is to be deemed appropriate by the Society.

7.2.9 Non-destructive Inspection

1. The propeller castings are to be subjected to the penetrant test deemed appropriate by the Society.

2. The ultrasonic or radiographic test is to be required if deemed necessary by the Society.

7.2.10 Repair of Defects

1. In event of finding defects which would be prejudicial to the proper application of propeller castings in service, the defects are to be removed by grinding, etc., and the surfaces of the ground depressions are to be as smooth as possible. Adequate non-destructive inspection is to be carried out to the repaired areas to ensure that all defects have been completely removed, and the repaired propeller casting is to be approved by the Society s surveyor upon the use in service.

2. Repair welding for the parts where defects were removed are to comply with the following requirements according to the zones for non-destructive inspection shown in **Fig. 7.1**.

(1) The areas according to Fig. 7.1 where repair welding are acceptable are to be as follows:

Zone A: Repair welding is not allowed

Zone B: Repair welding is allowed provided that prior approval was given by the Society

Zone C: Repair welding is allowed

(2) Prior to the weld repair on zone B or C mentioned in **(1)** above, a repair plan including welding procedures, welding consumables, edge preparations for weld repair after removing defects and heat treatment is to be submitted and approved by the Society.

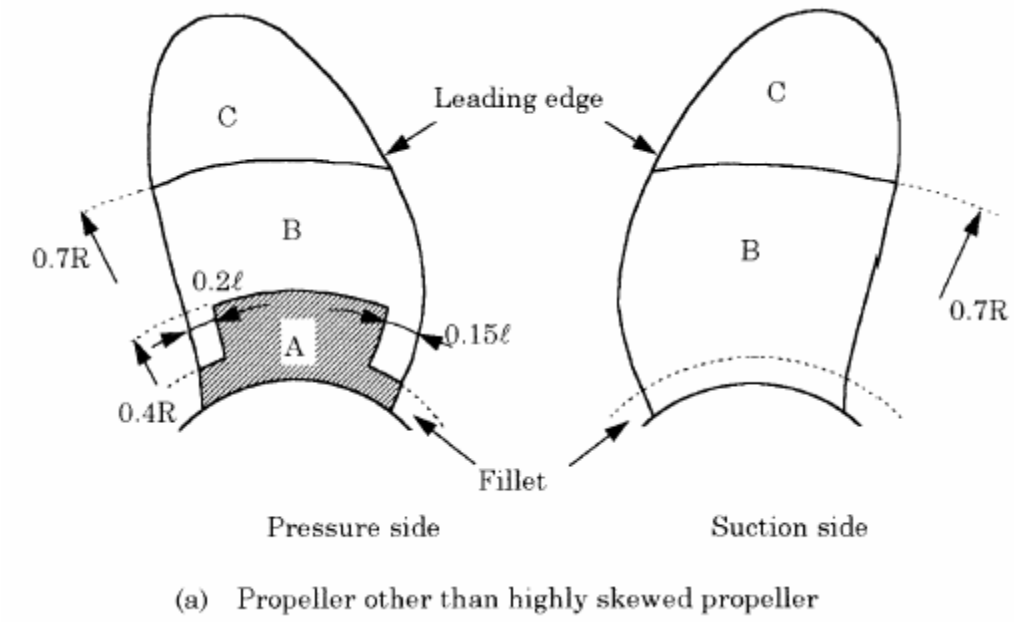
(3) An adequate non-destructive inspection is to be carried out on the welded areas to ensure that no defect exists.

3. The welding procedures are to be as deemed appropriate by the Society.

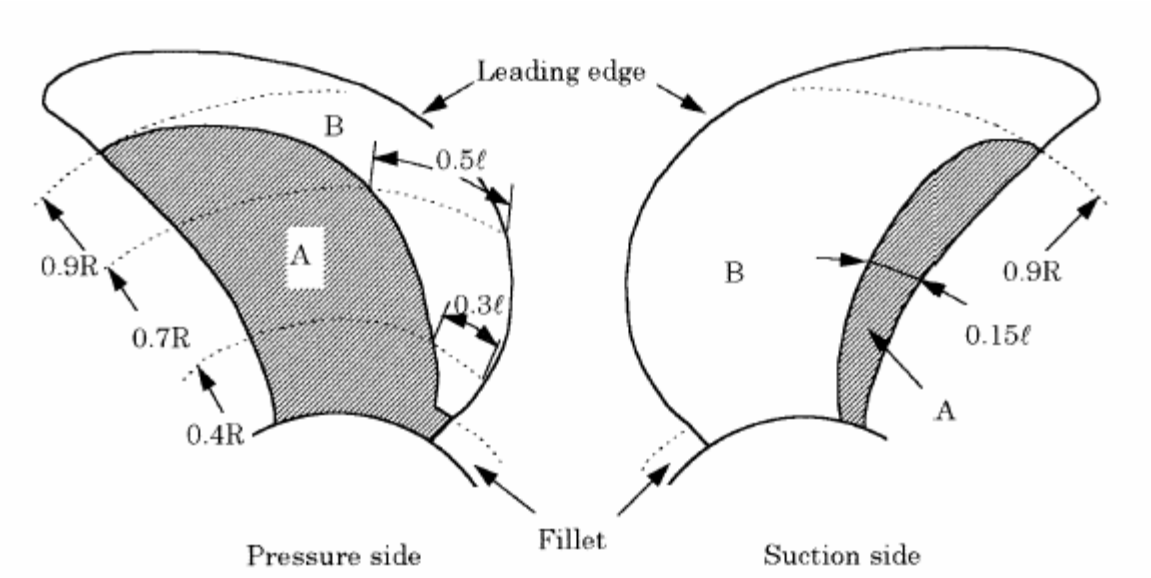
7.2.11 Marking

Marking for propeller castings is to comply with the requirements given in 5.1.12.

Fig. 7.1 Zones for Non-destructive Inspection



(a) Propeller other than highly skewed propeller



(b) Highly skewed propeller

Notes:

1 R is the radius of the propeller, ℓ is the chord length at any radius.

2 Highly skewed propeller is a propeller with a skew angle exceeding 25°.

3 The boss area of an integrally cast propeller is regarded as zone *C*.

4 The zones for non-destructive inspection in the root areas of controllable pitch or build up propeller blades and controllable pitch propeller bosses are to be deemed appropriate by the Society.

5 Where stress distribution on propeller blade surfaces is estimated in detail, the non-destructive inspection zones different from those shown in this figure may be applied provided the Society's approval.

Chapter 8 ALUMINIUM ALLOYS

8.1 Aluminium Alloy Plates and Extruded Shapes

8.1.1 Application

1. The requirements in this section are to apply to the plates and extruded shapes made of aluminium alloys (hereinafter referred to as "aluminium alloys" in this section.) intended to be used for tanks of liquefied gas carriers and for hull structures.

2. Aluminium alloys having characteristics differing from those specified in 8.1 are to comply with the requirements in 1.1.1-2.

8.1.2 Kinds

The aluminium alloys are classified as specified in Table 8.1

Table 8.1 Kind of Aluminium Alloys

Products	Material grade
Rolled Products	5083*P*
	5086*P*
	5383*P*
	5059*P*
	5754*P*
	5456*P*
	6061*P*
Extruded Shapes	5083*S*
	5383*S*
	5059*S*
	5086*S*
	6005*AS*
	6061*S*
	6082*S*

8.1.3 Chemical Composition

The chemical composition of aluminium alloys is to comply with the requirements given in Table 8.2.

8.1.4 Heat Treatment

The heat treatment (hereinafter referred to as temper condition) of aluminium alloys is subject to in Table 8.3.

8.1.5 Mechanical Properties

1. The mechanical properties of aluminium alloys are to comply with the requirements given in Table 8.3.

2. Where deemed necessary by the Society, other tests may be required in addition to the specified tests according to their application.

8.1.6 Selection of Test Samples

1. For test sample for rolled products, one test specimen is to be taken out of each one lot, except where specially approved by the Society. One lot is made up of rolled products:

(1) of which weight is not exceeding 2,000 *kg*;

(2) of the same alloy and from the same cast;

(3) of the same thickness;

(4) manufactured by the same process; and

(5) Having been submitted simultaneously to the same temper condition.

For single plates or coils weighting more than 2,000 *kg* each, one lot is made up of a single plate or coil.

2. For test samples for extruded shapes, except where specially approved by the Society, one test specimen is to be taken out of each one lot that is made up of extruded shape:

(1) not exceeding 1 *ton* where its nominal weight per one *meter* is less than 1 *kg/m*;

(2) not exceeding 2 *tons* where its nominal weight per one *meter* is not less than 1 *kg/m* and not more than 5 *kg/m*; or

(3) not exceeding 3 *tons* where its nominal weight per one *meter* is more than 5*kg/m*

(4) of the same product form and the same dimensions;

(5) manufactured by the same process; and

(6) having been submitted simultaneously to the same temper condition.

3. Test samples are to be taken out of the place at one third of the width from a longitudinal edge of rolled products, or in the range 1/ 3 to 1/2 of the distance from the edge to the centre of the thickest part of extruded products.

Table 8.2 Chemical Composition

Material grade	Chemical composition (%)										
	Si	*Fe*	*Cu*	*Mn*	*Mg*	*Cr*	*Zn*	*Ti*	Others [1]		*Al*
									Each	Total	
5083*P* 5383*S*	≤ 0.40	≤ 0.40	≤ 0.10	0.40-1.0	4.0-4.9	0.05-0.25	≤ 0.25	≤ 0.15	≤ 0.05	≤ 0.15	Remainder
5383*P* 5083*S*	≤ 0.25	≤ 0.25	≤ 0. 20	0.7-1.0	4.0-5.2	≤ 0.25	≤ 0.40		≤ 0.05 (4)	≤ 0.15 (6)	
5059*P* 5059*S*	≤ 0.45	≤ 0. 50	≤ 0. 25	0.6-1.2	5.0-6.0	≤ 0.25	0.40-0.90	≤ 0. 20	≤ 0.05 (5)	≤ 0.15 (6)	
5086*P* 5086*S*	≤ 0.40	≤ 0. 50	≤ 0. 10	0.20-0.7	3.5-4.5	0.05-0.25	≤ 0.25	≤ 0. 15	≤ 0.05	≤ 0.15	
5754*P*[2]		≤ 0. 40		≤ 0. 50	2.6-3.6	≤ 0.30	≤ 0.20				
5456*P*	≤ 0.25			0.50-1.0	4.7-5.5	0.05-0.20	≤ 0.25	≤ 0. 20			
6005*AS*	0.50-0.9	≤ 0. 35	≤ 0. 30	≤ 0. 50	0.40-0.7	≤ 0. 30	≤ 0. 20	≤ 0. 10			
6061*P*[3] 6061*S*[3]	0.40-0.8	≤ 0. 7	0.15-0.40	≤ 0. 15	0.8-1.2	0.04-0.35	≤ 0. 25	≤ 0. 15			
6082*S*	0.7-1.3	≤ 0. 50	≤ 0. 10	0.40-1.0	0.6-1.2	≤ 0. 25	≤ 0. 20	≤ 0. 10			

Notes:

1 When the existence of the other elements is presumed in the course of routine analysis, further analysis thereof is to be conducted.

2 $0.10 \leq Mn + Cr \leq 0.60$

3 $0.12 \leq Mn + Cr \leq 0.50$

4 $Zr \leq 0.20$

5 $0.05 \leq Zr \leq 0.25$

6 The total for other elements does not include Zirconium.

Table 8.3(a) Temper Conditions and Mechanical Properties[1] (Rolled Products)

Material grade	Temper condition [2]	Thickness t (*mm*)	Tensile test		
			Proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) [3] ($L = 5.65\sqrt{A}$)
5083P	0	t ≤ 50	125 min	275-350	14 min
		50< t ≤ 80	120-195	275-345	14 min
		80< t ≤ 100	110 min	265 min	
		100< t ≤ 120		260 min	12 min
		120< t ≤ 160	105 min	255 min	
		160< t ≤ 200	100 min	250 min	10 min
	H I11	t ≤ 50	125 min	275-350	14 min
	H I12			275 min	10 min
	H I16		215 min	305 min	
	H 321	t ≤ 50	215-295	305-385	10 min
		50< t ≤ 80	200-295	285-380	9 min
5383P	0	t ≤ 50	145 min	290 min	17 min
	H I11				
	H I16		220 min	305 min	10 min
	H 321				
5059P	0	t ≤ 50	160 min	330 min	24 min
	H I11				
	H I16	t ≤ 20	270 min	370 min	10 min
		20< t ≤ 50	260 min	360 min	
	H 321	t ≤ 20	270 min	370 min	
		20<t ≤ 50	260 min	360 min	
5086P	0	t ≤ 50	95 min	240-305	14 min
	H I11	t ≤ 12.5	125 min	250 min	-
	H I12	12.5< t ≤ 50	105 min	240 min	9 min
	H I16	t ≤ 50	195 min	275 min	
5754P	0	t ≤ 50	80 min	190-240	17 min
	H I11				
5456P	0	t ≤ 6.3	130-205	290-365	10 min
	H I16	t ≤ 30	230 min	315 min	
		30< t ≤ 40	215 min	305 min	
		40< t ≤ 50	200 min	285 min	
	H 321	t ≤ 12.5	230-315	315-405	-
		12.5< t ≤ 40	215-305	305-385	10 min
		40< t ≤ 50	200-295	285-370	
6061P	T6	t ≤ 6.5	245 min	295 min	-

Table 8.3(b) Temper Conditions and Mechanical Properties[1] (Extruded Shapes)

Material grade	Temper condition [2]	Thickness t (*mm*)	Tensile test		
			Proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) [3] ($L = 5.65\sqrt{A}$)
5083S	0	t ≤ 50	110 min	270-350	12 min
		50< t ≤ 130	110 min	275-355	10 min
	H I11	t ≤ 50	165 min	265 min	
			100 min	270 min	
	H I12				
5383S	0	t ≤ 50	145 min	290 min	17 min
	H I11				
	H I12		190 min	310 min	13 min
5059S	H I12	t ≤ 50	200 min	330 min	10 min
5086	0	t ≤ 50	95 min	240-315	12 min
			145 min	250 min	10 min
	H I11				
	H I12		95 min	240 min	
6005AS	T5	t ≤ 50	215 min	260 min	8 min
	T6	3< t ≤ 10			-
		10< t ≤ 50	200 min	250 min	6 min
6061S	T6	t ≤ 50	240 min	260 min	8 min
6082S	T5	t ≤ 50	230 min	270 min	6 min
	T6	3< t ≤ 5	250 min	290 min	-
		5< t ≤ 50	260 min	310 min	8 min

Notes:

1 Aluminium alloy may be subject to any other standards in lieu of the requirements given in this Table where they are approved by the Society.

2 Indication symbols used in temper condition are as follows:

O : Annealing

*H*111 : Work hardened

H 112 : As manufacturing process

H 116 : Stabilizing treatment after work hardened

H 321 : Stabilizing treatment after work hardened

*T*5 : Artificial age hardening treatment after elevated temperature working and succeeding cooling

*T*6 : Artificial age hardening treatment after solution treatment

3 The standards for elongation given in this Table applies to the tensile test using the proportional specimen for aluminium alloys whose thickness is more than 12.5 *mm*. Where test specimens other than the proportional specimens are applied to the tensile test or thickness of aluminium alloys is not more than 12.5 *mm*, the standards for elongation are subject to the discretion of the Society.

8.1.7 Selection of Test Specimens

Tensile test specimens are to be taken according to **(1)** to **(4)** below.

(1) One test specimen is to be taken out of each test sample.

(2) For rolled products, the longitudinal axis of the test specimen is to be taken transversely to the rolling direction. If the width is insufficient to obtain transverse test specimen or in the case of strain hardening alloys, however, the longitudinal direction may be taken parallel to the rolling direction.

(3) For extruded shapes, the longitudinal axis of test specimen is to be taken parallel to the extruded direction.

(4) For thickness up to and including 40 *mm*, the longitudinal axis of the test specimen is to be located at a distance from the surface equal to half of the thickness. For thickness over 40 *mm*, the longitudinal axis of the test specimen is to be located at a distance from one of the surfaces equal to one quarter of the thickness.

8.1.8 Corrosion Resistance Test

1. For aluminium alloys specified in **Table 8.3(a)** in the *H*111, *H*112and *H*116 and *H*321 tempers intended for use in marine hull construction or in marine applications where frequent direct contact with seawater is expected, corrosion resistance test is to be carried out.

2. For corrosion resistance test sample, one test specimen is to be taken out of each one lot specified in **8.1.6-1**. In this case, the weight of one lot may exceed 2 *tons*. Test samples are to be taken out of the place at mid part of the plate width.

3. Corrosion resistance test means that metallographic examination or corrosion tests for exfoliation corrosion resistance and intergranular corrosion resistance. Testing method and judging criteria are left to discretion of the Society.

8.1.9 Surface Inspection and Dimensional Tolerance

1. Surface inspection and verification of dimensions are left to the responsibility of the manufacturer.

2. The underthickness tolerances of rolled products are to comply with the requirements given in **Table 8.4.**

3. Dimensional tolerance except those specified in **-2** above is left to the discretion of the Society.

Table 8.4 minus Tolerance for a Nominal Thickness (Rolled Products)

Nominal thickness t (*mm*)	Nominal width W (*mm*)		
	$W < 1500$	$1500 \leq W < 2000$	$2000 \leq W < 3500$
	Minus tolerance (*mm*)		
$3 \leq t < 4$	0.10	0.15	0.15
$4 \leq t < 8$	0.20	0.20	0.25
$8 \leq t < 12$	0.25	0.25	0.25
$12 \leq t < 20$	0.35	0.40	0.50
$20 \leq t < 50$	0.45	0.50	0.65

8.1.10 Quality

1. Aluminium alloys are to be of uniform quality and free from internal and surface harmful defects prejudicial to the use of the concerned material for the intended application.

2. Slight surface imperfections may be removed by smooth grinding or machining as long as the thickness of the materials remains within the tolerances specified in **8.1.9-2**.

8.1.11 Additional Tests before Rejection

1. When the tensile test from the first piece selected fails to meet the requirements, two further tensile tests may be made from the same piece. If both of these additional tests meet all of the requirements, the piece and the remaining pieces from the same lot may be accepted.

2. If one or both of the additional tests referred to above are unsatisfactory, the piece is to be rejected. However, the remaining materials from the same batch may be accepted provided that two of the remaining pieces in the batch selected in the same way, are tested with satisfactory results.

8.1.12 Marking

1. Aluminium alloys, which have satisfied with the required tests, are to be marked with the identification mark in accordance with the requirements in **1.5.1**. In this case, the mark of temper conditions is to be put subsequent to the mark of material grade. For aluminium alloys, which have satisfied with the corrosion resistance tests specified in **8.1.8**, the mark of "*-M" i*s to be put subsequent to the mark of the temper condition, for example, "6005*AS-T5-M"*.

2. In case of aluminum alloys applied to other standards in accordance with the provision of **Note (1)** of **Table 8.3**, "*-YP"* , altered value and *M* where proof strength is altered or "*-TS"* , altered value and "*M"* where tensile strength is to be put subsequent to the mark specified in **-1**, for example, 6005*AS-T5-M-YP200M* .